



## **Forensic Fridays: Lesson Plans**

A Virtual Experience from the National Museum of Health and Medicine

### **National Museum of Health and Medicine's Mission:**

*To preserve and explore the impact of military medicine*

### **National Museum of Health and Medicine's Vision:**

*To preserve, inspire, and inform the history, research, and advancement of military and civilian medicine through world-class collections, digital technology, and public engagement*

### **Description:**

Forensic science involves the medico-legal investigation of criminal activities. *Forensic Fridays* is an educational program designed to highlight the disciplines involved in forensic science. Based on the museum's exhibit, "Human Identification," this program will focus on the United States' commitment to identification of service members. The Defense POW/MIA Accounting Agency and the Armed Forces Medical Examiner System consider a case resolved when 1) the American returns alive, 2) the remains are recovered, repatriated, and identified, or 3) when there is convincing evidence that neither 1) nor 2) is possible.

In this program, students will practice a variety of identification activities that contribute to a case study of an unknown individual and are used in forensic cases. These activities include some of the following: recovery and examination of material evidence, dental charting, developing a biological profile, and DNA analysis. During each session, students are given an overview of the session topic and a group activity relating to the case study. At the end of the 12 sessions, students will compile and compare their collected data to identify the unknown service member in the case study. All activities, including optional activities, are included in the provided lab notebook. This lesson plan, the lab notebook, and the forensic resource images are designed to be used together for a comprehensive lesson on forensic science facilitated by a teacher.

**Suggested time per lesson/activity:** 45-90 minutes

**Suggested group size:** minimum 7 students, maximum 35 students

**Suggested grades:** 5-8

## Lesson 1: Introduction, the Scientific Method, and a Case Study

### Objectives

At the conclusion of this session, the students should be able to:

1. Define the term “forensic science”
2. Define and use the scientific method process
3. List the six lines of evidence used to identify human remains
4. Define the terms “antemortem” and “postmortem”
5. Identify the organizations involved in the recovery, repatriation, and identification of unknown service members

### Background

This session is designed to give an introduction to forensic sciences, the scientific method, and the case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. The program lasts about 60 minutes. **To prepare for this activity, choose one pen and prepare the unknown samples for the group. Each group will have one set of three possible pens of different types and one “unknown sample letter.”**

### Outline of Presentation

#### What is forensic science?

Look for a near definition: **Forensic Science** is the medico-legal investigation of criminal activities or deaths. It can also be described as the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system. This term is used to cover a variety of professions that utilize their skills to support or help law enforcement with investigations. Some of the disciplines or professions include:

- Anthropology
- Odontology
- Pathology
- Engineering
- Accounting
- Criminalistics
- Psychiatry
- Toxicology

The United States is unique in that it strives to identify and return all service members to their families after their death. A variety of military or federal agencies are involved in the

identification of service members either during current or past conflicts. Some of these organizations are:

- Armed Forces Medical Examiner System, AFMES
- Defense POW/MIA Accounting Agency, DPAA
- Federal Bureau of Investigation, FBI
- Casualty and Mortuary Affairs Operations Division, CMAOD

### **What is forensic identification?**

Look for a near definition: **Forensic Identification** is the application of science to establish a personal identity, where the methods and results used can withstand scrutiny in a court of law. Every method of identification is based on a process of comparison of postmortem and antemortem data sets. Postmortem data are an individual's physical characteristics recovered and recorded by scientists from a body's remains after death (fingerprints, dental charting and X-rays, a biological profile, and DNA analysis; visual recognition is also considered postmortem data that can be used in a tentative identification.) Antemortem data are records of physical characteristics that a person is born with and which they acquire throughout life (medical records with annotations of height, weight, hair color, shoe size, scars, and tattoos, dental charts documenting restorations, cavities, and extractions, both dental and chest X-rays, X-rays of broken bones, and stored blood and fingerprint cards.)

To make a positive identification, six lines of evidence are used:

- Material Evidence
- Biological Profile
- Fingerprints
- Dental Identification
- DNA Identification
- Autopsy

Two out of the three scientific lines of evidence—fingerprints, dental, and DNA—are required to make a positive identification.

### **How did the field of forensic science develop?**

The professional field of forensic science has been in existence for roughly 150 years. Several individuals throughout the mid-19th century and early-20th century developed key principles and techniques that have formed modern forensic science.

**Alphonse Bertillon** is known for developing the first scientific system of personal identification. This system was similar to creating a biological profile in forensic anthropology. Bertillon's system became the early form of anthropometry, using human body measurements as individual characteristics. In the early 1900s, fingerprints replaced the Bertillon system as a unique identifier.

**Francis Galton** performed the first study of fingerprints as unique identifiers. He also developed the methodology of classifying fingerprints for filing.

**Hans Gross** wrote the first paper describing the use of the **scientific method** in criminal investigations.

**Edmond Locard** took Gross' theory one step further by applying the theory to criminal investigation techniques. One of Locard's most important theories developed during his career is **Locard's exchange principle**. This principle states that when two objects come into contact with each other, there is an exchange of materials or matter between them. An example of this principle is trace evidence or fingerprints.

Many other scientists or professionals developed important theories and discoveries such as blood typing, ballistics, and document identification.

### **What do forensic scientists do?**

Forensic scientists often specialize in topics related to their field of study. Anthropologists create biological profiles and assist with mass casualty disasters, entomologists determine time of death using insects, and others may classify fingerprints. All forensic scientists follow the same set of functions:

1. Analysis of evidence
2. Providing expert testimony
3. Training in the proper recognition, collection, and preservation of evidence

In this program, we will focus on identifying, collecting, and analyzing evidence.

### **Introduction to the Case Study**

During this program, you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams during each session with a focus on the six lines of evidence to identify the remains of the unknown individual. Not all of the activities will be related to the case study, as you will see noted in the lab notebook.

Your lab notebook contains all 12 activities related to the case study as well as optional activities.

### **Ink Chromatography Activity**

Review the process of performing the activity and the activity scenario. Review the process of the scientific method. **Note: The facilitator will need to create a "sample letter" using one of the pens. Students will take a piece of the letter with pen markings to use for the activity.**

## Introduction

You work for the chromatography division of a forensics lab. You have been asked to analyze accounting documents that may have been altered. You have pens from three possible suspects. You must determine which suspect altered the documents. Since pen manufacturers use different combinations of ink formulations to produce black pens, there may be variation in the mixture of colors. This activity will help you determine which suspect altered the documents. *This activity does not relate to the case study.*

## Materials

1 large beaker  
1 bottle of water  
3 paper clips  
3 pieces of litmus paper or coffee filters  
1 ruler  
1 pencil  
1 set of 3 pens of different types (felt tip, ball point, etc.)  
"Sample Letter"  
Paper towels  
Hole punch

## Procedure

1. Fill out the top portion of the data sheet. As a team, you will hypothesize which suspect (pen) altered the documents.
2. Cut a piece of litmus paper or coffee filter from the "sample letter."
3. Use the hole punch to punch a hole in the piece of the paper at the opposite end of the pen marking.
4. Thread one opened paper clip through the hole.
5. Hook the paper clip to the pencil and place the pencil across the top of the beaker.
6. Slowly add water to the beaker until it makes contact with the paper. Do not cover the ink marks.
7. Wait for the water to be absorbed by the paper.
8. Remove the paper from the water and set on a paper towel to dry.
9. To test the potential pens, make a mark on three separate pieces of paper and label each paper. Repeat steps 2-8. Make sure the three samples do not touch each other.
10. Record your observations on the data sheet.

## What is the Scientific Method?

**Scientific Method:** A method of research where data is collected and a hypothesis is made or proven.

Steps:

- Ask a question
- Research the question
- Make a hypothesis

- Test your hypothesis by doing an experiment
- Analyze your data and draw a conclusion
- Communicate your findings

### **Analysis**

1. What did you observe on the paper strips after you added water?
2. Did all the ink dots move?
3. Did all the ink dots form the same pattern (shape and color)?
4. Were you able to identify the ink used to alter the documents?

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, ask the attendees or students to complete the analysis section of the chromatography lab notebook section.
- Review the questions in the analysis section. You may include additional questions about chromatography or the scientific method.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity related to using the scientific method following the chromatography activity.
- Briefly explain the next session: forensic archaeology.

## Lesson 2: Forensic Archaeology

### Objectives

At the conclusion of this session, the students should be able to:

1. Define “forensic archaeology”
2. Explain the role of the Defense POW/MIA Accounting Agency
3. Define “recovery mission”
4. Describe the procedures for recovering evidence

### Background

This session is designed to give an introduction to forensic archaeology and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded by reviewing the data collected during the activity. This session will last about 90 minutes. **To prepare this activity, begin by filling the tub/box with potting soil or sand. As you fill the tub/box hide examples of material evidence in the sand or potting soil. The evidence should be at different depths. At the completion of this activity, the evidence should be placed in a bag for the following session.**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

#### What is archaeology or an archaeologist?

Look for a near definition: **Archaeologists** are professionals that collect, study, and use clues to understand past lives and culture. Archaeologists may need to uncover and gather materials to understand these past events.

#### What is forensic archaeology?

Look for a near definition: **Forensic Archaeology** is the use or application of archaeology to forensics or criminal investigations. Forensic archaeology may also include the search and recovery of human remains. This can apply to the recovery and repatriation of service members from previous conflicts.

**Repatriation:** The act of returning something to its origin (country or owner).

The United States is unique in that it strives to identify and return all service members to their families after their death. A variety of military or federal agencies are involved in the search and recovery of service members from past conflicts. These organizations are:

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- Defense POW/MIA Accounting Agency

### **What do the acronyms POW, MIA, and KIA stand for?**

There are three different casualty categories for service members during a war or conflict. The government uses acronyms for these names. An acronym is the word formed by using the initial letters of other words.

**Prisoner of War or POW:** A service member who is captured by enemy combatants and taken prisoner.

**Missing in Action or MIA:** Service members who were never proven to be safely returned, captured, or killed during a mission.

**Killed in Action or KIA:** Death of a service member by enemy combatants.

### **What do forensic archaeologists actually do?**

Forensic archaeologists attempt to find clues and understand past events/crimes at an archaeological site. An archaeologist or other team members use a process to determine the location of the site and collect all possible material. Archaeologists use three basic phases to do an excavation project. They will perform investigations and interviews, survey/test the site, and excavate the site collecting data.

### **What are the steps to an excavation project?**

An excavation project can also be referred to as a dig. The excavation project can be divided into the following phases:

**Investigation:** This includes background research on the event. Archaeologists or researchers may look at eye witness testimony (accounts), old maps, historical documents, or interview witnesses.

**Testing:** After the site or location of the incident is determined, a surface and subsurface survey occurs. These surveys will include walking the area, removing any shrubbery/brush, flagging unusual items, mapping the area, and creating a record of the survey. This is not considered a full excavation.

**Data Recovery (Excavation):** This is the phase where the full excavation occurs. Once the full excavation begins, any previously unrecorded associated context (marks in the stratigraphy) will be destroyed. This is why it is important to record all information during the testing phase. During the excavation, data is collected and recorded. Information on the location of objects and associations to other finds (objects) is key.

**Excavation Process:** Soil is organized by stratifications or layers. As you dig, you will find natural levels where the soil changes in type and texture. These levels allow archaeologists to determine the estimated time period and the events that occurred, and if other finds relate to the initial investigation. A basic grid is made as small as 1x1 meter squares. This grid helps archaeologists record and map the object locations. As the excavation occurs, mapping the location of objects and soil is important, as well as

recording information and depth levels. All soil is sifted/screened to make sure all parts of objects are collected. It is important to record the location of the removed soil. Once all the data is excavated and collected, the recovered materials will be evaluated for relevance and usefulness. Today, we will be performing the recovery portion of the excavation process. Next lesson, we will be evaluating the collected material evidence.

**Material Evidence:** Evidence that is relevant to a case.

### **Introduction to the Case Study**

During this 12-session program, you will be investigating a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each month with a focus on the six lines of evidence to identify the remains of the unknown individual. Not all of the activities will be related to the case study as noted in the lab notebook.

Your lab notebook contains all 12 activities related to the case study and also optional activities.

### **Recovery Project**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You are part of a recovery team working for Defense POW/MIA Accounting Agency and have been approved to travel to Cambodia for a recovery mission. You have been provided with an approximate area of a Huey wreckage site. You have done the initial investigation and spoken to eyewitnesses. You have also tested the area, tentatively, marking it with flags where you located evidence. You will now excavate the site, collect any items found and record your findings.

### **Materials**

2' x 2' tub/box filled with sand or potting soil  
Roll of string  
Roll of tape  
Pencil  
Graph paper  
Bucket  
Mesh Wire  
Trowel or Spoon  
Ruler  
Level  
1 gallon resealable bag  
Artifacts (hidden in the dirt layers)

### Procedure

1. Using the graph paper, draw a map of the surface of the dirt. Note an object or mounds.
2. Measure the sides of the box with a ruler. The sides will be marked in 10 centimeter intervals.
3. Run a piece of string across the box so that it touches the dirt. The string must be level, so test the string with a level. Continue until a grid of strings is created.
4. Work in one section at a time, removing small layers across the box. As you remove the dirt, filter the dirt through the wire placed on top of the bucket. Each layer of dirt must be removed at the same layer across the box.
5. Continue to remove thin/small layers across the box until an artifact is exposed. Record the depth from the string grid to the location of the object found. Record the depth in the data table.
6. Sketch the location of the object on the graph paper.
7. Place recovered artifacts in the plastic bag.

### Analysis

1. Did you find any objects or clues on the surface of the dirt?
2. What objects did you uncover during your excavation?
3. Based on objects excavated, describe what you “know” about the individual.
4. Why was it important to remove one layer at a time and to record your findings?
5. Why are the skills of an archaeologist useful in helping to solve forensic cases?

### Facilitating the students working on the activity

While the students are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary. Make sure the 2’x2’ plots are filled with sand or dirt and the evidence prior to the start of the activity. Students should collect the evidence in the resealable bags to be used in the next session.

### Conclusion

After about 30-40 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the recovery lab notebook section.
- Review the questions in the analysis section. You may include additional questions about forensic archaeology, DPAA, or excavations.
- Ask for any additional questions or comments.
- Briefly explain the next session: material evidence. Students should keep the objects they recovered in a bag or box for the next session.

## Lesson 3: Material Evidence

### Objectives

At the conclusion of this session, the students should be able to:

1. Define “material evidence”
2. Explain the functions of the Defense POW/MIA Accounting Agency
3. Define “recovery mission”
4. Describe the procedures for recovering evidence
5. Describe the role of material evidence in a case

### Background

This session is designed to give an introduction to forensic archaeology and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 75 minutes. **Prepare for the activity by providing students with a set number of Lego® Bricks. Students should also be using the material evidence collected from the previous session.**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

#### Review-What is archaeology or an archaeologist?

Look for a near definition: **Archaeologists** are professionals that collect, study, and use clues to understand past lives and culture. Archaeologists may need to uncover and gather materials to understand these past events.

#### Review-What is forensic archaeology?

Look for a near definition: **Forensic Archaeology** is the use or application of archaeology to forensics or criminal investigations. Forensic archaeology may also include the search and recovery of human remains. This can apply to the recovery and repatriation of service members from previous conflicts.

**Repatriation:** The act of returning something to its origin (country or owner).

The United States is unique in that it strives to identify and return all service members to their families after their death. A variety of military or federal agencies are involved in the search and recovery service members from past conflicts. These organizations are:

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- Defense POW/MIA Accounting Agency

## **\*\* Part A: Lego® Bricks Activity (perform this activity as a review of the Recovery Mission)**

### **Introduction**

After performing an excavation or “recovery,” you discover several pieces of material evidence that may relate to the unknown service member. You must first “re-create” the events of the crash and determine if the evidence uncovered belongs to one of the missing individuals.

### **Materials**

Bag of Lego® Bricks

Graph paper

Pencil

Boards

### **Procedure**

1. In your group, choose one person to create an object with the Lego® Bricks, the other person will “re-create” the object later.
2. With a divider/board between you, the “creator” will build a small object with the Lego® Bricks.
3. The “creator” will develop a map or instructions to recreate the object.
4. After making the map, the “creator” will deconstruct the object and pass the Lego® Bricks and map to the “re-creator.”
5. The “re-creator” will then reconstruct the object based on the map.

### **Analysis**

1. What was the Lego® Bricks object?
2. Did the map help you to rebuild the Lego® Bricks?
3. How difficult was it to “re-create” the object?

## **Part B: Material Evidence**

### **What is material evidence?**

**Material Evidence** is often personal effects or other pieces of evidence that could be used in an investigation. Personal effects are items that are often carried by or associated with an individual.

### **What are examples of material evidence?**

Material evidence could be jewelry, plane wreckage, ID cards, wallets, uniforms, dog tags, or anything else found at the scene.

### **How is material evidence used?**

Material evidence can be used to create a tentative identification of an individual. This tentative identification may not be always be accurate. DPAA uses material evidence to help narrow possible decedents in conjunction with other information. Archaeologists pay particular attention to artifacts or material evidence found in close proximity to the remains. This may include the area and same stratigraphy as the remains. Investigators must be careful when using material evidence in a case because the material may be commingled (mixed together) with other remains. Items may have been dropped at the location at a later date, or may not belong to the unknown individual at all. Researchers or scientists carefully examine the evidence to determine their use, accuracy, and relationship to the remains. Once this information is determined, it will help to narrow the number of possible decedents and even reconstruct the events surrounding the unknown individual's death.

### **Material Evidence Case study**

Civilian Case: VanRyn/Cerak. Briefly describe the van crash where two college women were misidentified based on their ID cards. <https://www.nytimes.com/2006/06/03/us/03mixup.html>

Military Case: Michael Joseph Blassie. Briefly describe the [Blassie](#) case.

### **Review of the Case Study**

During this 12-session program you investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual. Not all of the activities will be related to the case study, as noted in the lab notebook.

Your lab notebook contains all 12 activities related to the case study, and optional activities. You will need your lab notebook for each session of the program.

### **Material Evidence Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

Your team has completed an initial excavation of a site of a downed Huey (UH-1H) helicopter in Cambodia. You have collected several pieces of material evidence from the recovery mission. You must now record all the items collected and determine if these objects are relevant to the case.

### **Materials**

Evidence bag containing objects excavated during the dig  
Reference document

### **Procedure**

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1. Empty the contents of the evidence bag on the table.
2. On the data sheet, record the objects in the data table.
3. Next to the list in the data table, make inferences about the owner, last date of use and past events relating to the evidence.
4. Using the reference sheet, determine if the material evidence collected is relevant to the case.

### **Analysis**

1. What types of objects were recovered from the excavation site?
2. Were there any objects that didn't fit the case or story?
3. What can these objects tell you about the individual(s) involved in the crash?
4. Which of the three unknown service members do you believe the materials belong to?
5. Did the research help you to narrow the identity of the remains?

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20 minutes or when most of the groups have completed the activity, provide a conclusion. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already done so, have the attendees or students complete the analysis section of the recovery lab notebook section.
- Review the questions in the analysis section. You may include additional questions about forensic archaeology, DPAA, or material evidence.
- Ask for any additional questions or comments.
- Notify the group that there is an optional "Penny Activity" following the first session.
- Briefly explain the next session: creating a biological profile and sex estimation.

## Lesson 4: Biological Profile and Sex Estimation

### Objectives

At the conclusion of this session, the students should be able to:

1. Define “forensic anthropology”
2. Define and explain what comprises a biological profile
3. Define “articulated” versus “disarticulated”
4. Describe the anatomical features used to estimate the sex of an individual
5. Describe the difference between gender and sex
6. Describe the difference and impact of understanding the difference between human and non-human remains

### Background

This session is designed to give an introduction to sex estimation and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes. **Note: If you have a 3D printer, you may also download the data set and print your own cow bone from <http://www.morphosource.org/Search/Index?search=NMHM>**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past two sessions, we have performed a recovery mission and reviewed material evidence possibly relating to the case study. In the next three sessions, we will work in larger teams to create a biological profile of the unknown individual. A skeleton model will be used as a reference.

### What is biological anthropology?

**Biological Anthropology** is a science that studies human biology by looking at human and non-human primate evolution, variation, and adaptation. One area of study includes the analysis of human skeletal remains for scientific, historical, or legal purposes.

**Skeletal Anatomy:** Using the articulated skeleton or a skeletal diagram such as, <https://medlineplus.gov/ency/imagepages/1115.htm>, review the bones of the body. Participants will then fill out the skeleton worksheet.

### What is forensic anthropology?

Look for a near definition: **Forensic Anthropology** is the study of human remains in a medico-legal setting. Forensic anthropologists separate co-mingled remains, identify human versus non-human remains, and create a biological profile.

**Non-Human Remains:** Any remains that are not human, such as deer, raccoon, or dog.

To begin, forensic anthropologists can assist with determining if the bone(s) presented are human or non-human. For example, if you came across this bone in the woods, you might wonder if you stumbled upon a crime scene. So, you take it to the police. The police may need to show the bone to a biological anthropologist and ask if it is an animal bone or a human bone. [Show the cow foot bone] Is this human or non-human? [Take a show of hands for either answer] What kind of bone does it look like? [Take a few answers, most common answer is “dog bone.”] This bone actually belongs to a cow! It is part of the foot.

### What is a biological profile?

A **Biological Profile** is an estimation of an individual’s height, age, sex, and sometimes, ancestry. This profile is not 100 percent accurate; this is due to variations in human populations (you may need to define “population” as used in anthropology). As a result, these estimations do not fall under one of the three scientific lines of evidence. However, a biological profile is one of the six lines of evidence used to help lead investigators to the possible identity of an individual. Using the recovered specimens, forensic anthropologists place the bones in anatomical order on a table. This provides an inventory of all the bones available to help with the process of creating a biological profile (reference an example of a skeleton such as [www.visiblebody.com](http://www.visiblebody.com).) Often, investigators may not be able to recover a full skeleton. Therefore, you must learn to investigate the bones that are available to you.

### What anatomical features could be used to identify you?

*Answers will vary.* Features could include teeth, femur, humerus, pelvis, cranium, skin, hair, and DNA.

### Sex Estimation

To start creating a biological profile, we will begin with sex estimation. This will be part one of a three-part biological profile (sex, age, and height).

**Gender vs. Sex:** [Briefly describe the differences; this is to enforce using the correct terminology.] You may have heard the terms “gender” and “sex” used interchangeably, but they mean very different things. **Sex** is the biological characteristics or differences between males and females, including variations between the two. (**Note: There are at least six identified biological sexes, i.e. XX, XXY, XY, XYY, etc.**) **Gender** is considered a social or cultural construct and how you identify yourself, i.e. boy, girl, or non-binary; it is not tied to your biology.

### Sex Determination

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What bones in the body could help you estimate the sex of an individual? *Answers may vary but should include the skull/cranium and pelvis/hips.* The cranium and the pelvis may be used to estimate an individual's sex. The following are a few features to look for in the cranium or pelvis.

**Cranium:** [use examples to show each feature]

- Brow ridge
- Nuchal crest
- Mastoid process
- Zygomatic arch

**Pelvis:** [use examples to show each feature]

- Sciatic Notch
- Sacrum
- Pelvic inlet
- Subpubic angle

### **Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual. Not all of the activities will be related to the case study as noted in the lab notebook.

Your lab notebook contains all 12 activities related to the case study and also optional activities.

### **Biological Profile: Sex Estimation Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You are working in the Anthropology Division of the Defense POW/MIA Accounting Agency. You have received a set of remains from the case #1862. You are tasked to create a biological profile of the individual. Your first task is to create an estimation of the sex of the unknown individual.

### **Materials**

Lab notebook

Pencil

Male and female pelvis images from the PowerPoint

Male and female cranium images from the PowerPoint

Reference image from the PowerPoint (starred)

Sex estimation reference sheet

Skeleton worksheet

Cow bone image from the PowerPoint

### **Procedure**

1. Begin by reviewing the anatomy of the human skeleton. Fill out the skeleton worksheet.
2. Using the sex estimation reference sheet, record your findings in the data table.

### **Analysis**

1. Which bones did you use to estimate the sex of the individual?
2. What features on the bone(s) led to your conclusion?
3. What is the estimated sex of the individual?

### **Facilitating the students working on the activity**

While the students are completing the lab activity, to be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, discuss the results. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Biological Profile: Sex Estimation.
- Review the questions in the analysis section. You may include additional questions about forensic anthropology, biological profile, or sex estimation.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity “Word Search” focused on forensic vocabulary.
- Briefly explain the next session: creating a biological profile and age estimation.

## Lesson 5: Biological Profile and Age Estimation

### Objectives

At the conclusion of this session, the students should be able to:

1. Define “forensic anthropology”
2. Define and explain a biological profile
3. Place skeletal remains in anatomical order
4. Locate and describe distal vs. proximal locations on specimens
5. Describe the difference between adult and sub-adult remains
6. Describe the anatomical features used to estimate the age of an individual

### Background

This session is designed to give an introduction to age estimation and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes.

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past two sessions, we have performed a recovery mission and reviewed material evidence possibly relating to the case study. In the next three sessions, we will work in larger teams to create a biological profile of the unknown individual. An example of a skeleton will be used as a reference.

#### **Review: What is physical anthropology?**

**Biological Anthropology** is a science that studies human biology by looking at human and non-human primate evolution, variation, and adaptation. One area of study includes the analysis of human skeletal remains for scientific, historical, or legal purposes.

**Review: Skeletal Anatomy:** Using the articulated skeleton, review the bones of the body. Participants will then fill out the skeleton worksheet.

#### **Review: What is forensic anthropology?**

Look for a near definition: **Forensic Anthropology** is the study of human remains in a medico-legal setting. Forensic anthropologists determine human vs. non-human remains and then create a biological profile.

### **Review: What is a biological profile?**

A **Biological Profile** is an estimation of an individual's height, age, sex, and sometimes, ancestry. This profile is not 100 percent accurate; this is due to variations in human populations (may need to define populations as used in anthropology). As a result, these estimations do not fall under one of the three scientific lines of evidence. However, a biological profile is one of the six lines of evidence used to help lead investigators to the possible identity of an individual. Using the recovered specimens, forensic anthropologists place the bones in anatomical order on a table. This provides an inventory of all the bones available to help with the process of creating a biological profile. [Reference an example of a skeleton such as [www.visiblebody.com](http://www.visiblebody.com)] Often investigators may not be able to recover a full skeleton. Therefore, you must learn to investigate the bones that you have available.

### **What anatomical features could be used to identify your age?**

*Answers will vary.* Features could include teeth, femur, humerus, pelvis, and cranium.

### **Age Estimation**

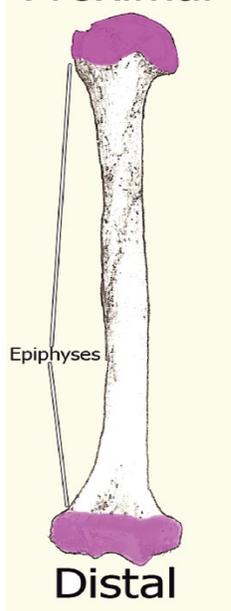
The next step in creating a biological profile is determining the age (at death) estimation. This will be part two of a three part biological profile (sex, age and height). You are born with over 300 bones in your body. Once you are fully grown, you have 206 bones in your body. As you grow, some of your bones fuse together at different rates, and after you have completed growing, your bones begin to deteriorate and show examples of wear until death. This information can be used to create estimated age ranges. Male and female bones also grow at different rates. It is important to determine the sex of the individual to help narrow the age ranges. Since an exact age cannot be determined, the biological profile cannot be 100percent accurate for a positive identification. (*May want to tie back to material evidence and false ages on ID cards.*)

**Adult vs. Subadult:** [Briefly describe the differences] Everyone is familiar with the word "adult." How would you define that word? *Answers may vary.* Do you know what sub-adult means? *Answers may vary.* **Subadult** (or immature skeletal remains) refers to all individuals under the age of 0-20 years of age. This includes neonate, infant, child, and adolescent. **Adult** skeletons after the approximate age of 21 begin to show wear and deterioration. It is very difficult to determine the sex of subadults due to pre-puberty features.

### **Age Determination**

When you are born, your long bones such as the humerus or femur, are in three parts: the diaphysis or shaft (the long part of the bone) and two epiphyses (proximal and distal ends). The epiphyses are separated from the long bone by a form of cartilage known as growth plates. As you grow, the shaft lengthens, and the growth plate begins to harden into the bone fusing the shaft to the epiphyses. Each end of the bone also fuses at different rates. This can

## Proximal



be determined by looking at the distal (distal=distance) and proximal (proximal=close to the body) ends of the bone. Based on these rates, you can determine the estimated age of an individual. If the individual is older than 27 years of age, the bones will be fused and you will begin to see signs of degenerative changes in the bone.

Ends of the Humerus	Male	Female
Proximal (shoulder end)	Grows together by age 25	Grows together by age 20
Distal (elbow end)	Grows together by age 18	Grows together by age 17

### Review of the Case Study

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual. Not all of the activities will be related to the case study as noted in the lab notebook.

Your lab notebook contains all 12 activities related to the case study and also optional activities.

### Biological Profile: Age Estimation Activity

Review the process of performing the activity and the activity scenario. Review the process of creating a biological profile.

### Introduction

You are working in the Anthropology Division of Defense POW/MIA Accounting Agency in Hawaii. You have received a set of remains from a crash site in Cambodia. After recording the estimated sex of the individual, you are now tasked with estimating the age of the individual.

### Materials

Lab notebook

Pencil

Image of humerus with epiphysis from the PowerPoint (starred)

Age estimation reference sheet

Skeleton Work sheet

**Procedure**

1. Compare the bones to the age reference sheet. Record your findings in the data table

**Data Table****Estimated Sex:**

<b>Proximal end</b>	<b>Fused</b>	<b>Unfused</b>
<b>Distal end</b>	<b>Fused</b>	<b>Unfused</b>

**Estimated age range:****Analysis**

1. What was the estimated age of the individual?
2. What parts of the bone were you able to use to estimate the age?
3. Why did you provide a range of ages?
4. Why would the age ranges be different for different sexes?

**Facilitating the students working on the activity**

While the students are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

**Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, discuss the results. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Biological Profile: Age Estimation.
- Review the questions in the analysis section. You may include additional questions about forensic anthropology, biological profile, or age estimation.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity to visit the [“Resolved” exhibit](#) on the NMHM website.

Briefly explain the next session: creating a biological profile and height estimation.

## Lesson 6: Biological Profile and Height Estimation

### Objectives

At the conclusion of this session, the students should be able to:

1. Define “forensic anthropology”
2. Define and explain a biological profile
3. Place basic specimens in anatomical order
4. Use an osteometric board
5. Describe and locate load bearing/long bones
6. Describe the process of estimating an individual’s height
7. Explain causes of discrepancies in recorded height

### Background

This session is designed to give an introduction to height estimation and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes.

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past three sessions, we have performed a recovery mission and reviewed material evidence possibly relating to the case study. In the next two sessions, we will work in larger teams to create a biological profile of the unknown individual. An example of a skeleton will be used as a reference.

### Review: What is physical anthropology?

**Biological Anthropology** is a science that studies human biology by looking at human and non-human primate evolution, variation, and adaptation. One area of study includes the analysis of human skeletal remains for scientific, historical, or legal purposes.

**Review: Skeletal Anatomy:** Using the articulated skeleton, review the bones of the body. Participants will then fill out the skeleton worksheet.

### Review: What is forensic anthropology?

Look for a near definition: **Forensic Anthropology** is the study of human remains in a medico-legal setting. Forensic anthropologists determine human vs. non-human remains and then create a biological profile.

**Review: What is a biological profile?**

A **Biological Profile** is an estimation of an individual's height, age, sex, and sometimes, ancestry. This profile is not 100 percent accurate; this is due to variations in human populations (may need to define populations as used in anthropology). As a result these estimations do not fall under one of the three scientific lines of evidence. However, a biological profile is one of the six lines of evidence used to help lead investigators to the possible identity of an individual. Using the recovered specimens, forensic anthropologists place the bones in anatomical order on a table. This provides an inventory of all the bones available to help create a biological profile. [Reference a skeleton examples such as [www.visiblebody.com](http://www.visiblebody.com)] Often investigators may not be able to recover a full skeleton. Therefore, you must learn to investigate the bones that you have available.

**How do you determine an individual's height?**

*Answers may vary.* You measure an individual from head to toe. What would you do if you can't measure an individual from head to toe? You measure the bones!

**Height Estimation**

The final step in creating a biological profile is determining height estimation. This will be part three of a three part biological profile (sex, age and height). Anthropologists estimate the height or stature of an individual to help create the biological profile. Anthropologists measure the entire skeleton, if available, or measure a long bone (otherwise known as a load-bearing bone or limb bone).

**Height Determination**

Forensic or physical anthropologists lay out the bones in anatomical order. If all of the bones are available, a measurement of the entire skeleton will be taken. An adjustment for lack of any soft tissue (muscle, ligaments or cartilage) is taken into account.

**What bones would you use to estimate the height?**

*Answers will vary. Lead students towards long bones or load-bearing bones.* Unfortunately, an entire skeleton is not always available. After placing available bones in anatomical order, a measurement of the limb bone or long bone will be taken. A tool called an osteometric board is used to measure the bone from the longest point on one end to the longest point on the other end. This measurement is taken in centimeters.

**Does this give you the actual height? How would you figure out the actual height from this number?**

Anthropologists use the statistical method of linear regression to estimate the height of unidentified individuals based on the length of long bones. The "regression formula" compares the long bone length of an unknown individual to long bone length data collected from bones of individuals whose living statures were known. In the 1950s, the anthropologist Mildred Trotter and statistician Goldine Gleser developed the first reliable regression formulae for use on a modern population based on data from American casualties of the Korean War and the

Terry Collection of anatomical human remains now housed at the Smithsonian Natural History Museum. The formula multiplies the centimeter value with a specific value based on the type of bone and the sex of the individual. This number is then converted from centimeters to inches and from inches to feet.

### **If you are using a formula, why is it considered an estimation?**

Although anthropologists use a formula to determine the height of the individual, there are many reasons why the number is still considered an estimation. Variables or factors need to be taken into account when estimating the height of an individual: the decedent may have a bone disorder or other illness causing the height to be different; the formula does not take into account soft tissue; there may be variables in differing populations; the individuals recorded height may include shoes or other additions. As a result, the minimum and maximum difference or intervals is only able to produce a 90-95 percent accuracy. Since this is not 100 percent, it can't lead to a positive identification and is considered an estimation of height or stature.

Today, we are going to finish creating a biological profile for our unknown service member. We need to determine which bone to use, measure it, and apply the formula to estimate the height.

### **Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study as well as take-home activities. Please remember to bring your lab notebook with you each time you attend the program.

### **Biological Profile: Height Estimation Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You work in the Anthropology Division at the Defense POW/MIA Accounting Agency. You are tasked with creating a biological profile of an unknown service member. The final part of creating the profile is to estimate the height of the individual. You will use a long bone to complete the profile.

### **Materials**

Lab notebook

Pencils

Osteometric board and ulna image from PowerPoint (starred)

Calculator

Skeleton worksheet

### Procedure

1. The ulna measures 25 centimeters. You will need to convert the height of the individual into feet and inches. Multiply the length in centimeters by 4. 27.  
\_\_\_\_\_ centimeters x 4.27= \_\_\_\_\_ centimeters
2. Add 57.97 to the length in centimeters.  
\_\_\_\_\_ centimeters + 57.97= \_\_\_\_\_ centimeters.
3. Convert the approximate height of the unknown person in feet and inches. Multiply by .3937 and divide by 12. \_\_\_\_\_ centimeters x .3937= \_\_\_\_\_ centimeters.  
\_\_\_\_\_ centimeters/12= \_\_\_\_\_ or \_\_\_\_\_ feet \_\_\_\_\_ inches.

### Analysis

1. Which bone did you use to estimate the height?
2. What is the estimated height of the individual?
3. Why are long bones or load bearing bones used to estimate height?
4. Even though you measured the bone and used an equation, why is this still considered estimation?
5. What is the biological profile for this individual?

Sex:

Age:

Height:

### Facilitating the students working on the activity

While the students are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### Conclusion

After about 20-30 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Biological Profile: Height Estimation.
- Review the questions in the analysis section. You may include additional questions about forensic anthropology, biological profile, or height estimation.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity "Height Estimation."

- Briefly explain the next session: DNA Identification.

## Lesson 7: DNA Identification

### Objectives

At the conclusion of this session, the students should be able to:

1. Define/describe “DNA”
2. Describe the functions of the DOD DNA Operations Division
3. Perform a DNA extraction activity
4. Determine the DNA sequence of the decedent

### Background

This session is designed to give an introduction to DNA analysis and the *Forensic Fridays* case study. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 90 minutes. **To prepare for this activity, the ethanol should be chilled in a freezer overnight, and the buffer solution may be mixed prior to the lesson or activity.**

**Tip: Frozen strawberries are preferred because they are flash-frozen at the peak of ripeness preventing rotting or breakdown of the fruit. Once defrosted they are also easier to use in the experiment.**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past six sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This month, we will be learning about DNA and determining the DNA of the unknown service member in the case study.

#### **Review: What are the six lines of evidence?**

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

#### **Review: What are the three scientific lines of evidence?**

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three must be present to make a positive identification. These lines are fingerprint, dental, and DNA identification.

This session we will be focusing on one of the three lines of scientific evidence: DNA.

### **What is DNA and where can it be found?**

*Answers may vary.* **DNA**, or deoxyribonucleic acid, is the genetic or heredity code (material) found in all living organisms. Human DNA makes us unique from other organisms and each human has unique DNA from other individuals. DNA can be found in the cell nucleus and the mitochondria of the cell.

### **How many types of DNA can you name? How are they used to identify an individual?**

*Answers may vary.* There are actually three types of DNA found in your body, but we are going to look at two types. They are nuclear DNA (nDNA) and mitochondrial DNA (mtDNA).

**Nuclear DNA** is located in the nucleus of the cell and can be retrieved from soft tissue, such as blood, hair, or skin. This type of DNA is a unique combination of both the parents. As a result, this DNA is completely unique to the individual. These DNA strands form the chromosomes in the nucleus of the cell.

**Mitochondrial DNA** is located in the mitochondria or powerhouses of the cell. This DNA is special because it can be found in more than just soft tissue, such as bones and teeth. This allows the DNA to be used years after death, such as in historical remains. Mitochondrial DNA is also passed down from the maternal (mother's) side of the family. *How might this make identification difficult?*

*\*Museum case study: If you have visited the Identifying Human Remains exhibit in the Collection That Teaches gallery, you will have noticed several Civil War bones on display. These bones were used to determine that mitochondrial DNA could be retrieved from historical remains (bones). Unfortunately, the process of DNA analysis requires that a portion of the specimen be ground into a powder to extract the DNA. This is considered destructive testing.*

The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). Human DNA consists of about three billion bases, and more than 99 percent of those bases are the same in all people. The order or sequence of these base pairs (AT, CG) determines the information available for building and maintaining an organism. This is similar to the way in which letters of the alphabet combine to form certain words and phrases. Each base pair always matches with a partner: A with T, and C with G. Each of these pairs is attached to a sugar and phosphate molecule. The base pair with the sugar and phosphate molecules are called a nucleotide. The nucleotides are arranged in long strands creating the double helix of DNA.

### **How is DNA used to identify an individual?**

This genetic code from the base pairs and phosphate groups create a unique order belonging to each human. As a result, the unique code can be matched from a sample to an individual.

**What are reference samples?**

*Answers may vary.* **Reference Samples** are samples of DNA (retrieved from soft tissue, blood, or bone) of a known individual. These samples are then used to match with the unknown sample. Not only can this provide a positive identification, but it can also assist in narrowing the number of possible identities.

**Review of the Case Study**

During this 12-lesson program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study and also optional activities.

**DNA Identification Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

Today's activity will involve removing the DNA of strawberries. Earlier, we discussed that DNA is located in the chromosomes of organisms. Each organism has a different number or chromosomes. Human chromosomes are grouped as diploids or pairs of two. In strawberries, the chromosome are grouped as octoploid or in bunches of eight. This larger number of grouped chromosomes will allow you to see the chromosomes or DNA with the naked eye.

**Introduction**

You are part of a team of analysts that work for the DOD DNA Operations division at the Armed Forces Medical Examiners System. You have received a bone sample of an unidentified service member killed in the Vietnam War. Maternal family reference samples have been collected from the families of the possible unknowns. After extracting the DNA, you must compare the unknown to the family reference samples.

**Materials**

Lab notebook

Pencil

1 quart-size resealable plastic bag

Frozen or fresh strawberries (frozen work better)

Cheesecloth

Sticks

Funnel

Buffer solution (liquid dish soap mixed with water and salt)

1 tablespoon liquid dish soap

1 teaspoon salt

1/3 cup water  
 Test tubes  
 Vials  
 10 ml ethanol chilled

### Procedure

1. Place the strawberries in a plastic bag.
2. Add 20 ml buffer solution to the bag. Mash and mix the strawberries and buffer solution.
3. Filter the seeds and excess pulp from the mixture by placing the cheesecloth over a test tube and pouring the solution into the tube. Squeeze the juice into the test tube.
4. Add 10 ml of the chilled ethanol to the test tube and wait 5-10 seconds.
5. Extract the DNA by pulling/spooling the DNA onto a stick. Place this in a vial.

### Analysis

1. Match the unknown sample to the family sample.  
 The unknown matches \_\_\_\_\_.  
 Unknown Sample: AAGTCCCTCTAAG  
 Woodward Family Sample: AGGTCCCCCTAAGATG  
 Otis Family Sample: AAGCCCTCTTAAGAGG  
 Russell Family Sample: AAGTCCCTCTAAGAGG
2. What is the difference between mitochondrial DNA (mtDNA) and nuclear DNA (nDNA)?
3. Why is it important to have a family reference sample?

### Facilitating the students working on the activity

While the students are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### Conclusion

After about 20-30 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the DNA Identification Activity.
- Review the questions in the analysis section. You may include additional questions about DNA.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity "DNA Identification."
- Briefly explain the next session: Dental Identification.

## Lesson 8: Dental Records and Identification

### Objectives

At the conclusion of this session, the students should be able to:

1. Understand the role of forensic dentistry or odontology in making a positive identification
2. Use dental records to make an identification of an unknown individual
3. Explain the different aspects of forensic dentistry
4. Use dental charts to record information about a set of teeth

### Background

This session is designed to give an introduction to dental analysis. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes.

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past seven sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This month, we will be learning about dental analysis and will be analyzing dental records and a mandible.

### Review: What are the six lines of evidence?

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

### Review: What are the three scientific lines of evidence?

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three must be present to make a positive identification. These lines are fingerprint, dental, and DNA identification. This session we will be focusing on one of the three lines of scientific evidence: dental records.

### What can teeth tell us?

*Answers may vary.* There is actually a lot teeth can tell us. They can tell a scientist about the health of a person, help determine age, retrieve DNA, and even identify a person. Everyone’s

teeth are unique because of health, hygiene, disease, shape, dental work, and even how we bite or chew our food.

### **Why do we use teeth for identification?**

*Answers may vary.* Teeth are used for identification because each individual has a unique set of teeth. The unique characteristics can be analyzed through radiographs and close examination of each tooth. Teeth can also withstand fires up to 1600 degrees Fahrenheit, they resist decomposition, can contain DNA, and just about everyone has a dental record. One of the earliest identifications using teeth in the military was done by Paul Revere. Paul Revere was a silversmith, which included making dental implants and fillings out of silver. During the Revolutionary War, Major General Joseph Warren was killed at Breed's Hill. Following the battle, Warren's family asked Revere to identify the remains that were located in an unmarked grave. Revere was able to positively identify Warren's remains based on the identification of his own dental work on Warren's teeth. More information on this story is located on the museum's website,

[https://www.medicalmuseum.mil/micrograph/index.cfm/posts/2019/paul\\_revere\\_and\\_joseph\\_warren](https://www.medicalmuseum.mil/micrograph/index.cfm/posts/2019/paul_revere_and_joseph_warren)

Members of the military are required to have yearly dental exams not only for health and wellness, but to keep their dental records and radiographs up to date. Current radiographs and records allow for a more precise reference for identification.

### **How are teeth analyzed?**

*Answers may vary.* Adults have 32 permanent teeth. As a child, you actually have two sets of teeth! Your baby teeth or milk teeth, and your adult teeth. As you grow, your adult teeth push through the surface of the gums which causes you to lose your baby teeth.

There are four basic types of teeth based on their function. These are incisors, canines, premolars, and molars.

### **Types of teeth**

**Incisor:** Eight teeth located at the front of your mouth (four top, four bottom). They are shaped like chisels and help to bite and tear food.

**Canine:** Four teeth (two top and two bottom) that are sharp and pointed. They help to bite and tear food. They are located on either side of the incisors.

**Premolar:** Transitional teeth located between the canines and molars. There are total of eight (four top and four bottom) located on either side of the mouth. The premolars are flat in comparison to the canines and incisors. These teeth allow for grinding and chewing of food.

**Molar:** 12 teeth (six top and six bottom) located on either side of the mouth, after the premolars. These teeth are flat and are used for grinding and chewing. The second molars are also called the 12-year molars, while the third molars in this group are also called wisdom teeth. Wisdom teeth erupt during the young adult age and are often removed.

Each tooth has five surfaces that can be analyzed. These surfaces are called distal, occlusal, buccal, mesial, and lingual. When teeth are analyzed, forensic odontologists carefully examine each surface for shape, caries (cavities), and restorations (crowns or fillings, implants or other unique features). They also compare antemortem and postmortem radiographs for the same factors.

**What is forensic odontology or forensic dentistry?**

*Answers may vary.* **Forensic Odontology** or **Forensic Dentistry** is the use of dental science or dentistry in a medico-legal setting. It is also used in bite mark analysis, and the comparison of records to identify human remains.

**What tools are used in forensic odontology?**

*Answers may vary.* A variety of tools are used in forensic odontology. Odontologists will use dental records (antemortem and postmortem), dental casts, radiographs (X-rays) or dental imaging, and dental charting.

**What are dental records?**

*Answers may vary.* Dental records are also known as patient records. These records contain all correspondence, radiographs or X-rays, treatment, and insurance claims of the individual while they were alive. These records can provide valuable information on the status of the individual prior to death.

**What are radiographs?**

**Radiographs** are X-rays. Radiographs can be taken before and after death to help compare the different characteristics of the teeth. In the late 1970s and early 1980s, the Computer Assisted Postmortem Identification (CAMPI) software along with a portable radiograph machine helped to identify the victims of the U.S. Army 101st Airborne Division airplane crash in December of 1985. Today, radiographs are captured digitally and are analyzed with the WinID software. This software is faster and less expensive than producing radiograph films.

**Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study and optional activities.

**Dental Charting Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

**Materials**

The National Museum of Health and Medicine is an element of the Defense Health Agency  
2500 Linden Lane, Silver Spring, MD 20910 \*301.319.3300\* [www.medicalmuseum.health.mil](http://www.medicalmuseum.health.mil)

Pencil

Lab notebook

Antemortem radiographs from the PowerPoint

Postmortem radiograph from the PowerPoint

Mandible from the PowerPoint

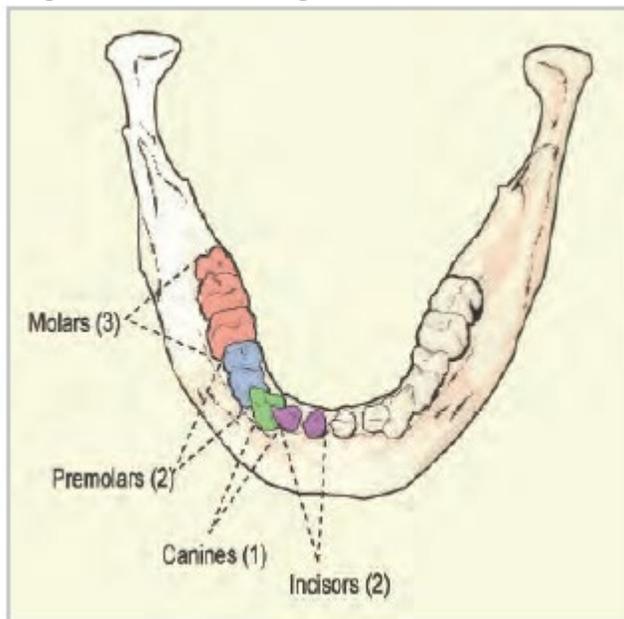
Dental charting forms

### Procedure

1. Compare the antemortem radiographs to the unknown postmortem radiograph.  
Record your findings.

DECEDENT	MATCH	
	YES	NO
WOODWARD	YES	NO
OTIS	YES	NO
RUSSELL	YES	NO

2. Using the dental charting form, record data related to the unknown mandible.



3. Using your dental charting form, record the information in your notebook.

Tooth type	Fillings (Yes/No)	Braces (Yes/No)	Erupted or Unerupted
Incisors			
Canines			
Pre-molars			
Molars			

**Analysis**

1. When comparing the radiographs or X-rays, what features or dental conditions did you observe?
2. Why do you need to use radiographs or dental charting forms?
3. After collecting the information, which information matched the unknown mandible?

**Facilitating the students working on the activity**

While the students are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

**Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, discuss the results. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Dental section.
- Review the questions in the analysis section. You may include additional questions about forensic odontology.
- Ask for any additional questions or comments.
- Briefly explain the next session: Fingerprinting.

## Lesson 9: Fingerprint Identification

### Objectives

At the conclusion of this session, the students should be able to:

1. Define fingerprint identification
2. Describe how fingerprints are a unique identifier
3. Identify the three basic types of fingerprints
4. Perform basic fingerprint analysis
5. Describe the process of retrieving fingerprints

### Background

This session is designed to give an introduction to fingerprint analysis. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes. **Tip: fingerprint cards or charts are available for purchase or download online.**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past eight sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This month we will be learning about fingerprint analysis and will be analyzing our own fingerprints.

#### **Review: What are the six lines of evidence?**

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

#### **Review: What are the three scientific lines of evidence?**

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three of these must be present to make a positive identification. These lines are fingerprint, dental, and DNA identification.

This session we will be focusing on one of the three lines of scientific evidence: fingerprints.

### What are fingerprints?

*Answers may vary.* **Fingerprints** are impressions created by ridges (friction ridges) on the tips of fingers, palms of hands, and soles of the feet. The purpose of the ridges is to help us grip things. Fingerprints are formed before a baby is born (during the fourth month of pregnancy), and maintain their pattern(s) throughout life.

### **What makes fingerprints unique?**

*Answers may vary.* Each person has a unique combination of patterns and ridge characteristics in their prints. This includes twins! Prints are divided into three types of ridges or patterns: loops, whorls, and arches. Loops can be found in about 65 percent of the population, whorls in 30 percent, and arches in about 5 percent. The combination of these ridges and minute details create a unique set of identifiers and can be systematically classified. Ridge characteristics (or minutiae) are the endings, bifurcations, enclosures and other ridge details found in the print (up to 150 different combinations). It is also nearly impossible to destroy one's own fingerprints.

As a result, there are no two prints that are alike, even in the FBI's database containing 50 million prints.

### **Why do we use fingerprints?**

*Answers may vary.* Fingerprints are used to identify individuals. This may include criminals, missing persons, or decedents. Fingerprints can also be used in background checks, secure logins, or other security related procedures. As a result, federal employees and military personnel are all fingerprinted when they begin their service. These records are kept on file in a large database called IAFIS (Integrated Automated Fingerprint Identification System) which is managed by the FBI. This database contains over 50 million records. These records can be pulled and used to identify military war dead, and any remains from a current conflict at the Armed Forces Medical Examiners System in Dover, Delaware. Specialized units from the FBI work at AFMES to identify fingerprints. Disaster Squads are also deployed from the FBI to identify fingerprints in mass casualty disasters such as plane crashes.

### **Where and how are fingerprints found?**

*Answers may vary.* Prints can be found on areas called friction skins, this includes the areas on the palms of your hands and feet, toes, and finger tips. Prints from individuals can be found anywhere, but are determined by the type of print and can be effected by the type of surface (porous vs. non-porous). Most prints can be divided into three types. Each type also requires a different method of retrieval. Today, we will be using basic methods of visible and latent prints.

**Visible Prints:** Prints deposited using a visible material such as blood or ink.

**Plastic Prints:** Prints impressed in a soft surface.

**Latent Prints:** A fingerprint made by the deposit of oils/perspiration. These prints are normally invisible to the naked eye.

### **How are fingerprints compared?**

To compare fingerprints you need to have a known sample. To identify a service member you will need a list of possible decedents and their fingerprint records. Once the records are pulled, a set of prints will be retrieved from the unknown decedent. In some cases of decomposition, the top layer of skin can be removed known as “postmortem de-gloving.” Once the top layer of skin is removed, the skin can be worn as a glove to retrieve the prints. Due to age or work, some individuals may have thin or worn ridges; this involves some ink and light pressure to retrieve the print.

Once all of the prints for the known and unknown individuals are collected, a specialist in fingerprint identification looks at the ridges and minutiae at a minimum of 12 points to make an exact and final match. This includes the ridge endings, bifurcations, enclosures, and other ridge details. IAFIS can aid in the identification, however the final determination is made by the specialist.

### **What are the three principles of fingerprinting?**

As a review the following are the three principles of fingerprinting:

- A fingerprint is an individual characteristic: no two fingers have yet been found to possess identical ridge characteristics.
- A fingerprint remains unchanged during an individual’s lifetime. Fingerprints have general ridge patterns that permit them to be systematically classified.

### **Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study, and optional activities.

### **Fingerprinting Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You are currently working for the Federal Bureau of Investigation in the fingerprint identification department. You have been asked to help match fingerprints to individuals of a mass casualty airplane crash. *This activity is not part of the case study.*

### **Materials**

Lab notebook  
Makeup or paint brush  
Cocoa powder

Clear tape  
Clear or transparent glass or jar  
Fingerprint cards or white paper (cards can be purchased online)  
Black ink  
Hand wipes  
Ruler  
Scissors

### **Part A: Procedure**

1. Make a fingerprint on the glass or jar.
2. Lightly brush some cocoa powder on the glass using the makeup brush.
3. Pull off a piece of clear tape large enough to cover the print , plus at least 1 inch on each end (total should be about 3 inches). You may use a ruler to measure the tape. Do not cut the tape until step 5.
4. Slowly begin pressing down the tape onto the glass ovetop of the fingerprint, using finger pressure. Note: try to avoid creating air bubbles under the tape and smudging the print.
5. Cut the tape from the roll and carefully, using the free end of the tape, remove the tape from the surface of the glass.
6. Mount the lifted print here:

### **Part B: Procedure**

1. Create a fingerprint card. Begin by filling out some of the information at the top of the white piece of paper.
2. Roll your finger from left to right on the ink pad, making sure to cover as much surface of your fingertip as possible.
3. Place the print (also rolling left to right) on the paper. Repeat this for all 10 fingers.
4. Record your observations of loop, whorl, or arch for your print. Make sure to mark left or right hand.

### **Analysis**

1. Why do investigators collect fingerprints?
2. What did you notice about your fingerprints?
3. What are some reasons that people may need to be fingerprinted?

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Fingerprint Activity.
- Review the questions in the analysis section. You may include additional questions about fingerprinting.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity “Visible Proofs.”
- Briefly explain the next session: Trauma Identification.

## Lesson 10: Trauma Identification

### Objectives

At the conclusion of this session, the students should be able to:

1. Define the three types of trauma: blunt force, sharp force, and gunshot wound
2. Describe types of pathology
3. Identify causes and locations of a few examples of trauma

### Background

This session is designed to give an introduction to trauma identification. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes. **Note: If you have a 3D printer, you can download datasets for bones exhibiting trauma from Morphosource to be used as hands-on examples of trauma** <http://www.morphosource.org/Search/Index?search=NMHM>.

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past nine sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This session we will be learning about trauma analysis and will be analyzing trauma on a bone.

#### Review: What are the six lines of evidence?

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

Today we will be focusing on trauma identification.

#### Review: What are the three scientific lines of evidence?

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three must be present to make a positive identification. These lines are fingerprint, dental and DNA identification.

#### What is trauma?

*Answers may vary.* **Trauma** is an injury or wound to the body caused by another source. This can be caused by a variety of factors, such as falling from a tree or a car accident. Today, when we talk about trauma we will primarily refer to the impact on bones.

### **What the types of trauma?**

*Answers may vary.* Forensic anthropologists or scientists divide the types of trauma into four categories as they relate to death investigations. These types are blunt force, sharp force, and gunshot wounds, and thermal trauma.

**Blunt Force Trauma:** Injuries or wounds caused by blunt objects such as the butt of a rifle, a hammer, or a baseball bat.

**Sharp Force Trauma:** Injuries or wounds caused by sharp objects, such as knives, sabers, or glass. Both sharp force and blunt force may include multiple wounds, however, you cannot determine the blade type from the wounds.

**Gunshot Wounds:** Injuries or wounds caused by guns. Types are determined by the type of bullet. Gunshot wounds have unique characteristics based on caliber or gauge which result in unique entry and exit wounds.

**Thermal Trauma:** Trauma as a result of being exposed to extreme heat. This includes bodies retrieved from fires. A pattern of damage, including muscle shrinkage, flaking, and delamination, can be seen with this form of trauma.

### **What is physics? Why do you need to understand physics to understand trauma?**

*Answers may vary.* **Physics** is the study of matter and its motion in space and time. Physics helps us understand how energy and force relate to objects. This information can help forensic scientists understand the cause of trauma and its effects on the body.

**Energy:** Capacity for doing work.

**Force:** A push or pull on an object. In regards to trauma, the force is the tension or compression on the object, such as a bone. This leads to fractures.

By applying this knowledge to equations, forensic scientists can determine the entry and exit wounds, pressure, and cause of the trauma.

### **What are other factors that might impact the understanding of trauma on the body?**

*Answers may vary.* When investigating the causes of trauma on bones, other factors need to be taken into consideration. This includes understanding the intrinsic (internal factors, such as health) and extrinsic (external factors such as environmental exposure) factors of the bone or individual, the type of strain placed on the bone, and types of fractures.

### **Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study, and additional take-home activities. Please remember to bring your lab notebook with you each time you attend the program.

### **Trauma Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You are a forensic anthropologist working with Defense POW/MIA Accounting Agency and have been asked to create a biological profile for an unknown service member repatriated from the Vietnam War. You have already estimated the sex, age, and height of the individual. You also have patient records from the three possible decedents in the crash, and eyewitness testimony from the sole survivor, Brinton. As part of the biological profile, you must determine if the individual had any antemortem trauma, and probable cause of death.

### **Materials**

Lab notebook

Decedent's bone from the PowerPoint (starred)

Bones with trauma from the PowerPoint

### **Procedure**

1. Compare the image of the unknown bone with images of the bones showing examples of trauma. Record your observations.
2. Compare the above findings to those of the three possible decedents.

### **Analysis**

1. What information can be observed by looking at bones with trauma?
2. Was there anything unique about the unknown individual's bones?
3. Did you observe any visible signs of trauma on the unknown service member's bones?
4. Which decedent did your observations match?

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, discuss the results. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Trauma Activity.

- Review the questions in the analysis section. You may include additional questions about trauma identification.
- Ask for any additional questions or comments.
- Briefly explain the next session: Microscopy.

## Lesson 11: Microscopic Analysis

### Objectives

At the conclusion of this session, the students should be able to:

1. Describe physical evidence
2. Describe trace evidence
3. Define identification
4. Define comparison
5. Identify types of trace evidence

### Background

This session is designed to give an introduction to microscopic analysis of trace evidence. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60 minutes. **To prepare for this activity, collect six different hair samples and one unknown trace evidence sample. The trace evidence sample should match with one of the six samples.**

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past 10 sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This session, we will be learning about trace evidence and microscopic analysis.

#### **Review: What are the six lines of evidence?**

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

#### **Review: What are the three scientific lines of evidence?**

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three must be present to make a positive identification. These lines are fingerprint, dental, and DNA identification.

#### **What is physical evidence?**

*Answers may vary.* **Physical Evidence** is any object or item that can be used in a criminal investigation to prove that either a victim or criminal are tied to a crime scene. There are two

important aspects to keep in mind when reviewing physical evidence: identification and comparison.

**Identification:** This is the process of determining an object's physical or chemical identify. An example is drug analysis.

**Comparison:** The basic concept of comparing and contrasting to determine whether two or more objects have the same or common origin. One example is ballistics.

### **What is trace evidence?**

*Answers may vary.* **Trace Evidence** is a type of evidence that is transferred from one object to another via contact.

### **What are some examples of trace evidence?**

*Answers may vary.* Examples of trace evidence can include hair, clothing fibers, or paint.

### **Where can trace evidence be found?**

*Answers may vary.* Trace evidence can be found in a variety of locations depending on the point of transfer. Paint could be transferred to another hard object, such as a hammer, car, or even a skull (as we saw last month). Hair and fibers could be found on clothing or other objects, such as carpets.

### **How is trace evidence useful in a criminal investigation?**

*Answers may vary.* Trace evidence can be used and analyzed to link a suspect or victim to a crime scene.

### **How are microscopes used in criminal investigations?**

*Answers may vary.* The use of microscopes can be vital in a criminal investigation. Microscopes can be used to analyze physical evidence to determine chemical and biological properties. Microscopes, such as the comparison microscope can also be used to compare and contrast related evidence. This may include identifying the type of bullet from a weapon, or hair samples found at the crime scene.

### **How is data collected from trace evidence?**

*Answers may vary.* Data from trace evidence may include biological and chemical compounds of the evidence, or images, such as photomicrographs. This information will aid in determining a match to a known sample and may lead investigators to a suspect or those with a relationship to the victim.

### **Compound Microscope Review**

We will be reviewing the basic aspects of a compound microscope before starting today's activity.

*How many have used a basic microscope before?* If you have, you should be familiar to the basic parts of a compound microscope. Compound microscopes are microscopes that magnify

small objects. It uses an objective lens with a very short focal length combined with a longer focal lens in the eye piece. Both lenses are mounted on the same tube.

A **Comparison Microscope** is a microscope that combines two compound microscopes to allow for easy comparison of specimens.

A **Stereoscopic Microscope** allows for higher magnification and definition of specimens as compared to the compound microscope.

For today's activity, we will be using compound microscopes.

### **Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study, and additional take-home activities.

### **Microscope Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

### **Introduction**

You are working with the Trace Evidence Unit of the Federal Bureau of Investigation. You have collected various types of trace evidence from a crime scene. You must compare the evidence found to those of the suspects. *This activity is not part of the case study.*

### **Materials**

Lab note book  
Compound microscope  
6 collected hair samples from different sources  
Unknown trace evidence slide  
Tweezers  
14 microscope slides

### **Procedure**

1. Look at the color of hair sample **A**. Record your observations in the **Data Table A**.
2. Using the tweezers, place the hair sample on the glass slide. Cover the hair sample with a second slide (like a sandwich), so that it can be viewed under the microscope.
3. Place the slide under the microscope. Be sure to adjust the settings to give a sharp image of the hair.

4. Draw a picture of the hair sample in **Data Table A**.
5. Repeat steps 1-4 for the other samples.
6. Look at the unknown sample under the microscope. Draw the unknown sample below. Compare this to your known samples.

### **Analysis**

1. Were you able to see variations in color of the samples?
2. Were you able to see variations in structures of the samples?
3. What do you think the hair samples can tell you about the organism?
4. Did the unknown hair sample match any of the known samples? If so, which one?
5. How were you able to determine a match?

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, bring the attention of the students to the front of the group. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Microscope Activity.
- Review the questions in the analysis section. You may include additional questions about trace evidence and hair samples.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity reading and discussion.
- Briefly explain the last session: Autopsy.

## Lesson 12: Autopsy Report and Conclusion

### Objectives

At the conclusion of this session, the students should be able to:

1. Compare and contrast information about the possible decedents
2. Compile information about the unknown service member
3. Define autopsy
4. Describe the role of DPAA and AFMES in creating a report
5. Identify the unknown service member

### Background

This session is designed to give an introduction to the development of an autopsy report. It will allow students interested in forensic science a way to apply their skills and get to experience “field work.”

### Logistics

The program will begin with a 15-20 minute introduction and discussion on the topic, followed by the activity, and concluded with a review of the data collected during the activity. This activity should last about 60-90 minutes.

### Outline of Presentation

The following introduction is a general script, not to be followed word for word. Cover the materials and information in your own words.

In the past 11 sessions, we have performed a recovery mission, reviewed material evidence, and created a biological profile. This session will be the conclusion of the series, with a focus on the final autopsy report.

#### **Review: What are the six lines of evidence?**

*Answers may vary.* There are six lines of evidence used to make a positive identification of an unknown decedent. These lines are: material evidence, fingerprinting, DNA identification, dental, anthropology or a biological profile, trauma and pathology.

#### **Review: What are the three scientific lines of evidence?**

*Answers may vary.* There are three lines of evidence that are considered scientific. Two out of the three must be present to make a positive identification. These lines are fingerprint, dental, and DNA identification.

#### **What is an autopsy?**

*Answers may vary.* An **Autopsy** is a postmortem examination to determine the cause of death. It can also be defined as a postmortem examination of the body. In this setting, we are using the term autopsy to describe the final report on the identity and cause of death for the unknown service member.

**Who compiles the information and creates the report?**

*Answers may vary.* A scientific director at DPAA compiles and reviews the information. After reviewing the information, the scientific director provides a memo identifying the individual and the information that led to that conclusion.

**How are families informed of an identification?**

Organizations such as the Defense POW/Missing Accounting Agency and the Service Casualty Office work as liaisons between the government and the families to provide information about the identification. The SCO can assist families with funeral arrangements and handling the media. This organization can also guide families in understanding the process of locating, repatriating, and identification of remains. It is extremely important to have accurate information and proof of identification before notifying the families.

**Review of the Case Study**

During this 12-session program you will investigate a fictional case study that occurred during the Vietnam War. You will be investigators for the Defense POW/MIA Accounting Agency. At the front of your lab notebook you are provided with the background of the case and three possible decedents. You will work as teams each session with a focus on the six lines of evidence to identify the remains of the unknown individual.

Your lab notebook contains all 12 activities related to the case study, and additional take-home activities.

**Autopsy Report Activity**

Review the process of performing the activity and the activity scenario. Review the process of the recovery project.

**Introduction**

You are the Scientific Director at the Defense POW/MIA Accounting Agency and you are tasked with compiling the information on the unknown service member. You have received scientific analysis of an unknown service member that was killed in a Huey (UH-1H) helicopter crash in Cambodia. You must compile all of the evidence and determine the identity of the unknown service member. This report will be sent to the Service Casualty Office which will contact and explain the results to the family.

**Materials**

Lab notebook  
Decedent information  
Autopsy data sheet

**Procedure**

1. Review the information in the autopsy data sheet and compare it to the information about the three possible decedents.

The National Museum of Health and Medicine is an element of the Defense Health Agency  
2500 Linden Lane, Silver Spring, MD 20910 \*301.319.3300\* [www.medicalmuseum.health.mil](http://www.medicalmuseum.health.mil)

2. Compile your information, and determine the identity of the unknown service member.

### **Analysis**

1. Was there any material evidence collected at the crash site? If yes, please list.
2. What is the biological profile of the individual?  
Sex:  
Age:  
Height:  
Trauma:
3. The unknown sample matched which mtDNA family reference sample.  
**Woodward, Otis, or Russell?**
4. The unknown dental sample matched which decedent's dental records.  
**Woodward, Otis, or Russell?**
5. Where fingerprints or trace evidence found with the remains?  
From your observations and collected information, record the identity of the individual and explain your answer.

### **Facilitating the students working on the activity**

While the attendees are completing the lab activity, be sure they understand the tasks and instructions. Answer questions if necessary.

### **Conclusion**

After about 20-30 minutes or when most of the groups have completed the activity, discuss the results. The following conclusion is a general script, not to be followed word for word. Cover the materials in your own words.

- If they have not already, have the attendees or students complete the analysis section of the Autopsy Report Activity.
- Review the questions in the analysis section. You may include additional questions about performing an autopsy, or the military's role in identification.
- Ask for any additional questions or comments.
- Notify the group that there is an optional activity reading and discussion.

## Vocabulary

### Key Concepts

Antemortem Data: Records of physical characteristics that a person is born with and which they acquire throughout life.

DPAA: Defense POW/MIA Accounting Agency (formally the Joint POW/MIA Accounting Command).

Exclusion: Identification results when postmortem data matches an individual's antemortem data to the exclusion of every other person (i.e. the comparison of data rules out the possibility that the remains are anyone other than the person identified).

Forensic Identification: The application of science to establish personal identity, where the methods and results used can withstand scrutiny in a court of law. Every method of identification is based on a process of comparison of two data sets.

Lines of Evidence: Scientific disciplines that contribute to identification and may include material evidence, fingerprinting, dentistry, anthropology, DNA, trauma and pathology.

Locard's Exchange Principle: This principle states that when two objects come in contact with each other, an exchange of materials occur between them.

Postmortem Data: An individual's physical characteristics recovered and recorded by scientists from a body's remains after death.

Repatriation: to send back a person's remains to his/her own country.

Resolved: A case is RESOLVED when 1) the American returns alive; 2) remains are recovered, repatriated, and identified, or 3) when there is convincing evidence that neither 1) nor 2) is possible.

Service Casualty Office: Military department that services as a liaison for families concerning personnel recovery and accounting.

### Material Evidence

Casualty Incident: The event surrounding a service member's death.

Decedent: A general scientific term that refers to a deceased individual (a person that has died).

Identification Tag: A tag worn by soldiers as a means of identification. These tags may include the name of the soldier, social security number, home address, and other important information. This is often called a “dog tag.”

Material Evidence: All non-living items associated and found with the remains of a person.

## **Anthropology**

Allometry: The correlation of the size of a bone to a person’s height.

Biological profile: The estimation of the skeleton’s (or unidentified person’s) age, sex, stature, ancestry, and any signs of trauma or pathology.

Endochondral Ossification: The replacement of cartilage with bone.

Epiphyses: The rounded end of the long bone, where growth plates are located.

Forensic Anthropology: The field of science that analyzes the human skeleton to create a biological profile for legal purposes.

Mass Fatality Incident: An incident that has a high fatality count that local emergency personnel cannot handle on their own (ex: hurricanes, airplane crashes, acts of terrorism).

Medico-Legal: The intersection of law and medicine in the process of making a scientific identification of human remains.

Minimum Number of Individuals: The total minimum number of individuals or people found among the remains or at an incident site.

Osteology: The study of the structure and function of the skeleton and bony structures.

Population: The collection of people or organisms of a particular species living in a given geographic area.

Pubic Symphyses: The midline cartilage joint that joins the left and right pubic bones.

Return of the Dead Program: Post World War II program to recover, return, and identify the remains of World War II soldiers.

Sexual Dimorphism: The differences between the sexes of the same species.

Skeletal Degeneration: Natural deterioration of the skeleton.

## DNA

Amplification: The process of making copies of a sample of DNA using an enzymatic reaction called the polymerase chain reaction (PCR) so that there is enough DNA to see for analysis.

Armed Forces Repository of Specimen Samples for the Identification of Remains: Maintained by the Armed Forces Medical Examiners System, this deep-freeze warehouse contains blood cards for U.S. service members and reservists that can be used as a reference to establish identification.

DNA: Deoxyribonucleic acid that is found in cells and can be analyzed to aid in the identification of human remains.

DNA Sequence: The succession of letters representing a structure of a strand of DNA, including a combination of the letters A, G, C, and T (A=adenine, G=guanine, C=cytosine, T-thymine).

Extraction: The process of extracting DNA from a specimen. To extract DNA from bone, a technician cuts it into fragments, sands it clean, pulverizes it into a powder with a blender, and dissolves it in solutions to release the DNA.

Gel Electrophoresis: The process of separating DNA fragments by size. Each base (A, G, T, and C) is labeled with a dye. An electrical field forces the fragments to travel through a gel. The rate and distance at which the fragments travel depend on their size. After separation, the DNA fragments can be viewed through an ultraviolet light.

Isolation: The process of removing and purifying DNA that is extracted from specimens.

Junk DNA: Also known as “spacers, 11,” this is the portion of DNA sequence that has no known function. They often contain repeated sequences of nucleotides called Short Tandem Repeats (STRs). The STRs of a person can be compared to the STRs of their mother and father to establish identification.

Mitochondrion: A round organelle within the cell but outside the nucleus, which produces energy for the cell. Mitochondria contain their own DNA that is different from nuclear DNA.

Mitochondrial DNA: DNA found in the mitochondria outside the cell nucleus. MtDNA is most commonly used in the identification of damaged skeletal remains.

Nuclear DNA: DNA found in the nucleus of human cells, consisting of long strings of the nucleotides A, C, T, and G.

Polymerase Chain Reaction (PCR): The process through which DNA is “amplified” or copied using an enzymatic reaction so there is enough DNA available for analysis.

Reference Materials: Items such as blood cards, cheek swabs, or samples from family members that can be compared to samples from human remains to establish identify.

Short Tandem Repeats: A short tandem repeat in DNA occurs when a pattern of two or more nucleotides (AGTC) are repeated and the repeated sequences are directly adjacent to each other. By examining enough STR loci and counting how many repeats of a specific STR sequence there are at a given locus, it is possible to create a unique genetic profile of an individual.

Visualization: The process of analyzing or viewing DNA after it has been processed through electrophoresis.

## **Dental**

Anterior Teeth: Incisors and canines, designed for biting and tearing.

Caries: A cavity or decay.

Dentition: The development of teeth and their arrangement in the mouth.

Distal: Away from the midline.

Endodontics: The sub-field of dentistry that deals with the tooth pulp and the tissue surrounding the root—endodontists specialize in root canals.

Facial: Surface toward the cheek or lips.

Incisal: Biting edge of the front teeth (canine and incisor).

Lingual: Surface toward the tongue.

Mandible: The mandible or “jawbone” is the strongest bone of the face. It forms the lower jaw and holds the teeth in place.

Maxilla: The bones that form the upper jaw.

Mesial: Toward the midline of the mouth.

Occlusal: The biting surface of the posterior teeth.

Posterior Teeth: Molars and premolars, used for grinding and chewing.

Radiograph: X-ray image.

WinID: A postmortem identification software that facilitates the comparison of multiple antemortem dental records to postmortem charts made from recovered remains. This software also includes the use of digital radiographs.

## **Fingerprints**

ACE-V: The acronym for the scientific methodology used to analyze fingerprints (analysis, comparison, evaluation, and verification).

AFMES: The Armed Forces Medical Examiner System. AFMES is the center of medical-legal investigations for the Defense Health Agency, and is responsible for determining the cause and manner of death for all active duty members who died within federal jurisdiction, as well as for identifying the deceased.

Fingerprint Kit: A portable kit used to retrieve fingerprints from an individual or object.

Friction Ridges: Contours in the skin's surface of the palms or soles of the feet that allow for better gripping action as a result of friction.

Friction Skin: Areas of the skin that contain friction ridges.

Ridge Flow: The flow or pattern of the friction ridges on the skin.

Minutiae: Points of interest in a fingerprint, such as bifurcations (a ridge splitting into two) and ridge endings.

## **Resources**

The appearance of hyperlinks does not constitute endorsements by NMHM or any other agency of the U.S. government of the destination website or the information, products, or services contained therein.

### Websites:

All About Forensic Science: <https://www.all-about-forensic-science.com/>

AFMES: Armed Forces Medical Examiner: <https://health.mil/Military-Health-Topics/Health-Readiness/AFMES>

DNA Information: <http://www.dnai.org/>

DPAA: Defense POW/MIA Accounting Agency: <https://www.dpaa.mil>

FBI: Federal Bureau of Investigation: <https://www.fbi.gov>

Morphosource: <http://www.morphosource.org/Search/Index?search=NMHM>

NMHM: National Museum of Health and Medicine: <https://www.medicalmuseum.health.mil>

VVMF: Vietnam Veterans Memorial Fund: <https://www.vvmf.org>

Virtual Wall: <http://www.thewall-usa.com>

Visible Proofs: <https://www.nlm.nih.gov/exhibition/visibleproofs/index.html>

## Publications

*Criminalistics: An Introduction to Forensic Science*, Richard Saferstein, 2011.

*Crime Scene Investigations: Real-life Science Labs for Grades 6-12*, Richard Platt, 2003.

*Crime Scene: The Ultimate Guide to Forensic Science*, Richard Platt, 2003.

*The Bone Detectives: How Forensic Anthropologists Solve Crimes and Uncover Mysteries of the Dead*, Donna M. Jackson and Charlie Fellenbaum, 1996.

*The Forensic Casebook: The Science of Crime Scene Investigation*, Ngaire E. Genge, 2002.

*Forensic Science* (DK Eyewitness Books), Chris Cooper, 2008.

*Talking Bones: The Science of Forensic Anthropology (Facts on File Science Sourcebooks)*, Peggy Thomas, 1995.

## Bibliography and Links

National Governors Associations Center for Best Practices and the Council of Chief State School Officers. (2020). *Common Core State Standards*. Retrieved from [www.corestandards.org](http://www.corestandards.org)

National Research Council. (1996). *National Science Education Standards*. Washington, D.C.: The National Academies Press.

NGSS Lead States. (2020). *Next Generation Science Standards: For States, By States*. Retrieved from [www.nextgenscience.org](http://www.nextgenscience.org)

*RESOLVED: Advances in Forensic Identification of U.S. War Dead* (Damann and Spatola, 2008)

## Education Standards

### Common Core

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

### Next Generation Science Standards

Use appropriate tools and techniques to gather, analyze and interpret data.

Think critically and logically to make the relationships between evidence and explanations.

Communicate scientific procedures and explanations.

Use mathematics and computational thinking in all aspects of scientific inquiry.

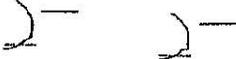
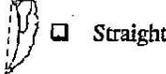
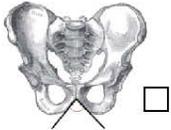
## Forensic Fridays:

### MISSING PERSONS DATA SHEET

<b>Brinton (Decedent #1) (antemortem data)</b>	<b>Woodward (Decedent #2) (antemortem data)</b>	<b>Russell (Decedent #3) (antemortem data)</b>
Sex: Female	Sex: Male	Sex: Female
Age: 35	Age: 19	Age: 20
Height: 5'7"	Height: 5'5"	Height: 5'4"
Pathology/Trauma: None	Pathology/Trauma: Healed fracture of ulna	Pathology/Trauma: None
Dental: Braces, no dental records available	Dental: Filling on left molar (17), wisdom teeth (molar 3) unerupted	Dental: Filling right molar 1, both molar 3 unerupted
mtDNA: AGGTCCCCCTAAGATGC	mtDNA: AAGCCCTCTAAGAGGC	mtDNA: AAGTCCCTCTAAGAGGG

Sex Estimation Reference Sheet

Case: \_\_\_\_\_

	FEMALE	MALE
<b>CRANIAL</b>		
Mastoid Process		
Zygomatic Arch		
Nuchal Crest		
Brow Ridge	 <input type="checkbox"/>	 <input type="checkbox"/>
<b>PELVIS</b>		
Sciatic Notch		
Sacrum	 <input type="checkbox"/> Straight	 <input type="checkbox"/> Curved
Subpubic Angle	 <input type="checkbox"/>	 <input type="checkbox"/>
Pelvic Inlet	 <input type="checkbox"/>	 <input type="checkbox"/>

## Compound Light Microscope Worksheet

Please use the words from this word list to identify the parts of the microscope. Place the identifying word on the line which points to that part of the microscope.

Arm	Eyepiece (ocular lens)	Objective lens, high power
Objective lens, low power	Base	Revolving Nose Piece
Coarse adjustment knob	Fine adjustment knob	Diaphragm (iris)
Light	Stage	Body Tube



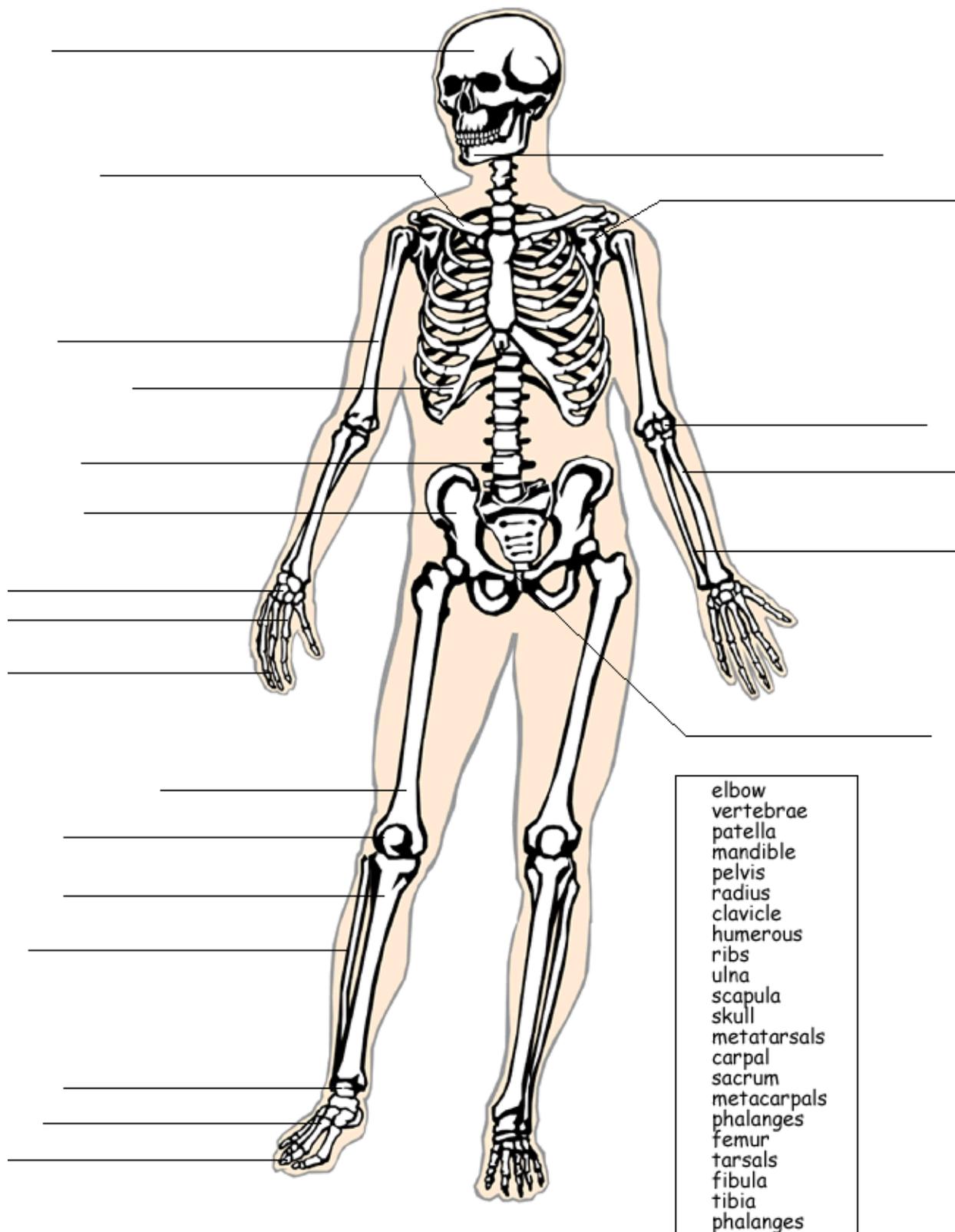
## Forensic Fridays:

### AUTOPSY DATA SHEET

Material evidence, the anatomical profile compiled by the forensic anthropologist, and trauma analysis may be used to determine a tentative identification and as supporting data for the investigation. In order to make a scientific identification, it is necessary to exclude all other individuals through the scientific analysis of fingerprints, dental records, and DNA. JPAC Central Identification Laboratory (CIL) requires that two of these scientific methods must confirm the identification of the individual in order for the case to be RESOLVED.

	<b>Unknown Service Member</b>
Material Evidence:	
Sex:	
Estimated Age:	
Estimated Height:	
Pathology/Trauma:	
Fingerprints:	
Dental:	
mtDNA:	

## Label the Skeleton



ANTEMORTEM DENTAL RECORD						
SSN	Last name	First name	MI	Sex	DOB/ Age	Race
				M F		C M N U
I.D. No.:			Date of Reconstruction:			
<p>MAXILLARY</p> <p>BUCCAL</p> <p>OCCLUSAL</p> <p>1 2 3 4 5 6 7 8   9 10 11 12 13 14 15 16</p> <p>Right Left</p> <p>32 31 30 29 28 27 26 25   24 23 22 21 20 19 18 17</p> <p>OCCLUSAL</p> <p>LINGUAL</p> <p>OCCLUSAL</p> <p>MANDIBULAR</p> <p>BUCCAL</p>						
~~~~~Computer Description Codes~~~~~				~~~~~WinID Symbols~~~~~		
1		17		PRIMARY CODES		SECONDARY CODES
2		18		C	CROWN	A ANOMALY
3		19		D	DISTAL	B PRIMARY TOOTH
4		20		F	FACIAL	E RESIN
5		21		I	INCISAL	G GOLD
6		22		J	MISSING/TRAUMA	H PORCELAIN
7		23		L	LINGUAL	N NONGOLD METAL
8		24		M	MESIAL	P PONTIC
9		25		O	OCCLUSAL	Q ¾ CROWN
10		26		U	UNERUPTED	R ROOT CANAL
11		27		V	NONRESTORED	S SILVER AMALGAM
12		28		X	EXTRACTED	T DENTURE TOOTH
13		29		/	NO INFORMATION	Z TEMP FIL/CARIES
14		30				
15		31				
16		32				
Remarks:				X-Ray type: _____	Date: _____	
				X-Ray type: _____	Date: _____	
				X-Ray type: _____	Date: _____	
				Examiners: _____		

POSTMORTEM DENTAL RECORD							
ID No.	Last name	First name	MI	Sex	Est. Age	Race	Date of Postmortem
				M F		C M N U	
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>MAXILLARY</p> </div> <div style="text-align: center;"> <p>MANDIBULAR</p> </div> </div>							
Computer Description Codes				WinID Symbols			
1		17		PRIMARY CODES		SECONDARY CODES	
2		18		C	CROWN	A	ANOMALY
3		19		D	DISTAL	B	PRIMARY TOOTH
4		20		F	FACIAL	E	RESIN
5		21		I	INCISAL	G	GOLD
6		22		J	MISSING/TRAUMA	H	PORCELAIN
7		23		L	LINGUAL	N	NONGOLD METAL
8		24		M	MESIAL	P	PONTIC
9		25		O	OCCLUSAL	Q	¾ CROWN
10		26		U	UNERUPTED	R	ROOT CANAL
11		27		V	NONRESTORED	S	SILVER AMALGAM
12		28		X	EXTRACTED	T	DENTURE TOOTH
13		29		/	NO INFORMATION	Z	TEMP FIL/CARIES
14		30					
15		31		X-Ray type:	_____	Date:	_____
16		32		X-Ray type:	_____	Date:	_____
Remarks:				X-Ray type:	_____	Date:	_____
				Examiners:	_____		

## Fingerprint Card

Name		Address		
R-Thumb	R-Index	R-Middle	R-Ring	R-little
L-Thumb	L-Index	L-Middle	L-Ring	L-Little
Left four fingers taken simultaneously		L-Thumb	R-Thumb	Right four fingers taken simultaneously