Title: **Forensic Biology**

Length of Course: **Full Year (2 semesters; 3 trimesters; 4 quarters)**

Subject Area – Discipline: **Laboratory Science ("d") - Integrated Life and Earth Science**

CTE Sector: **Public Services**

CTE Pathway: **Legal Practices**

Grade/Level(s): **9-11**

Course Overview:

In this course students study biology and earth science by engaging in investigations of how scientific evidence is used to solve crimes. Students take on the roles of public safety professionals to identify, collect, preserve, test, and analyze physical evidence. Each unit of this course asks how physical evidence can be used to solve a type of crime, and students explain and explore the scientific principles at work. Students learn not only how and why evidence can be used to solve crime, but also how biogeological processes affect the preservation and viability of physical evidence. Professional report writing is emphasized in this course, reflecting the high frequency and importance of writing reports in public safety careers. Throughout this course, students will collect and analyze evidence from simulated crime scenes. The course culminates with students using physical evidence to solve a simulated homicide and delivering expert testimony in a simulated murder trial.

Course Content:

Unit 1 - Burglary

Driving Question: How can fingerprints, hair and fibers, and blood evidence be used to solve a burglary?

In this unit students will investigate how forensic evidence can be used to solve a burglary. Students will learn about structure and function in living organisms on the cellular and molecular level, and will discover how forensic scientists use physical evidence to solve crime by collecting, testing, and analyzing biological evidence. Students will learn principles of cell structure and function and how they relate to analysis of different types of biological evidence, such as mtDNA, nuclear DNA, amino acids in fingerprints, and hair fibers. Students will learn how the use of blood evidence

has evolved in forensic science, and will explore the genetic breakthroughs that have allowed for this evolution. Students will apply principles of genetics to show how individuals with the same genotype can express different phenotypes, how phenotype can be affected by environmental factors, and how forensic scientists must factor this into their analysis of biological evidence. This unit will culminate with students analyzing a crime scene, collecting evidence, and solving a burglary case. Students will use the cellular and molecular evidence from the blood typing, DNA analysis, and the physical characteristics of fingerprints and hair fibers to solve who committed the burglary.

Unit 1 - Key Assignments

1: Evolution of Blood Evidence for Crime Solving

Students are presented with a scenario where a car was broken into in the school parking lot, and although no fingerprints or hair was found, the burglar cut himself on the broken glass and left behind blood evidence. Prior to completing this activity, students get instruction in heredity, molecular genetics, population genetics, statistical genetics, mendelian inheritance. For the project, students will work with a lab partner, and each group will have to determine who the culprit is by narrowing down a field of possible suspects. Students will test the blood evidence against blood samples from the possible suspects. (The actual criminal and one other subject should have the same blood type, and should have the same mother, and therefore the same mtDNA.) The series of tests that students undertake will be representative of tests that have become available as forensic science has evolved in complexity. Students will first carry out a blood typing test to narrow down the field. Next, students will run a gel electrophoresis of mitochondrial DNA to further narrow down the field. Finally, students will run a gel electrophoresis of a nuclear DNA sequence, such as a VNTR or STR, to make a final determination about who the actual criminal was. Each group will turn in a detailed lab report that identifies who committed the crime, explains each test that they did, what the results of the test were, and how they were able to use that evidence to narrow down the field. Explanations must include the scientific principles which would include heredity, molecular genetics, population genetics, statistical genetics, mendelian inheritance, and electrophoresis that each lab test is based on.

2: Fingerprints

In this assignment students will analyze a burglary/crime scene in which blood samples and fingerprints were left behind. The DNA matches the crime to a person who is an identical twin. Students will need to look at the structure of DNA and determine why DNA is not the best evidence to use when identical twins are suspects in a crime. Both suspects claim to be innocent. The students will have to determine who committed a crime based off of the fingerprints left behind. Genetic mutations, caused by the environment have an effect on the fingerprints of identical twins. The students will have to research the three basic fingerprint patterns and write a report on fingerprint analysis. Students will be given sets of fingerprints to test and analyze. They will then be given the fingerprints at the crime scene and the fingerprints of the twins to determine who committed the crime. Students will collect the fingerprint samples, analyze and

compare the loops, whorls ,arches and deltas in order to put them into a presentation (powerpoint, prezi, google slides). The analysis of the prints, a molecular explanation of why humans leave fingerprints, and an explanation of why identical twins have different fingerprints will be included in the presentation. The presentation will determine which twin committed the crime according to whose fingerprints were found at the crime scene.

3: Microscopy

During this assignment students will analyze a crime scene in which hair and fiber pieces were left behind. Using a microscope students will analyze the different hair and fibers samples. Hair samples have different color and structure depending on the suspect's' phenotype and genotype. Students will look at hair samples from the same person (same genotype) but the hair samples will be different colors because of dye (different phenotype). Students will also look at fibers of the same color and size but from different manufactures to see how different the fibers are under the microscope. Student groups will develop a model to classify how fiber and hair samples are similar and how they are different. Students will present their group classification of fiber and hair samples to the class. The class as a whole will then develop a model for classifying fiber and hair samples. Using the class model, students will compare hair and fiber samples taken from different suspects to determine who committed the crime. Students write a report stating who committed the crime and how that conclusion was determined based on the evidence. Students will use the report to plan their oral testimony in a deposition.

4: Burglary Crime Scene

A mock crime scene will be set up in the classroom. The students will be given background information on a burglary of a cell phone that occurred in the classroom. This scenario should include any of the above types of evidence (blood, fingerprints, hair, fiber). Students will work in groups of 3-4. Each group will process any evidence found using proper techniques and evidence packaging procedures. Each item of evidence will be submitted to the teacher as a case file to be placed in the property room.

Finally, the groups will analyze the found evidence, comparing it to three possible suspects. The workup of blood evidence should include determination of blood type, mitochondrial DNA analysis, nuclear DNA analysis. Fingerprint and fiber analysis should match the physical evidence with the phenotype of the criminal in question. Based on analysis of the evidence, groups will determine who committed the crime. Each group will make a presentation to the District Attorney (teacher) explaining why they believe that an arrest warrant should be issued for the suspect.

Unit 2 - DUI

Driving Question: How does understanding the function of body systems allow public safety officers to determine field sobriety?

In this unit students will learn how public safety officials use evidence to solve drug and alcohol related cases. Students will develop models which illustrate how drugs and alcohol impact individual body systems, interactions between body systems, and overall homeostasis of the body. Students will use these models to solve drug and alcohol related crimes. In this unit, students will learn to recognize the objective symptoms of various drug impairments, and will categorize those symptoms into a pocket-sized reference guide that could be used by law enforcement. Students will conduct investigations to determine how each organ and body system contributes to the overall maintenance of homeostasis, and how various substances alter this dynamic equilibrium. Students will analyze field sobriety tests commonly used by law enforcement, and evaluate how effective they are in various scenarios. This unit culminates with a social media public service announcement, where students utilize the knowledge and skills they acquired in the unit to spread awareness at their school site.

Unit 2 - Key Assignments

1: Using Objective Symptoms to Identify Drug Use

In this assignment, students will explore the mechanisms by which various drugs affect biochemistry, and how they impact homeostasis of the human body. Students will work in pairs to create a table which details information about common street drugs including name, category (ex. CNS stimulant, CNS depressant, hallucinogen, narcotic analgesics, etc., mechanism of action, and objective symptoms.) Each pair will use the information from their data table to create a pocket-sized quick reference guide that law enforcement could use to assess an individual and determine what drug they are most likely under the influence of and present them to a law enforcement officer. Each pair of students will create and present a scenario. These scenarios will demonstrate the student's understanding of homeostasis and how drugs affect the biochemistry of the human body. Then each pair will analyze the presented series of scenarios, and must match each scenario to a drug on their quick reference guide, and must submit a law enforcement template report including a justification of why they chose that drug.

2: Designing a Field Sobriety Test

Students will work in groups of 4 to research how alcohol affects human body systems and to create a field sobriety test that could be used by law enforcement. Each group of students will choose 4 physiological systems and write a research paper that analyzes how these systems work in concert to maintain homeostasis, and how alcohol interferes and interacts with these systems. Each group will research all current field sobriety tests. Then they will choose three field sobriety tests. The students will research which three are best to identify whether or not a suspect was under the influence of alcohol based on how alcohol physiologically affects humans. The students will then present their three sobriety choices to a panel of former and current police officers, who will choose which combinations that would most likely be utilized by law enforcement.

3: Outreach Assignment

In this assignment students will create a public service announcement using social media, based on their knowledge of the body systems and the effects of drugs and alcohol on them. Students will interact with an outside organization(s) to gain specific insight and information about the effects of drugs and alcohol on the body systems and their effects on human lives. Organizations may include Mothers Against Drunk Drivers (MADD), Narcotics Anonymous (NA), Alcoholics Anonymous (AA), Red Ribbon Week, Every 15 Minutes, and First Responders (Police, Fire, or Paramedics). It may be done using Youtube, Facebook, Snapchat, Instagram, Vine, etc. The announcement will be shown at the school site. As community connection for public safety, one presentation will be selected by the class and will be presented at the local school board or local public and private agencies.

Unit 3 - Anthropological Crime Scenes

Driving Question: What is the viability of ancient evidence and how can it be used?

In this unit, students will learn and use techniques and principles of forensic anthropology in a variety of settings. Students will act as the defense in a simulated court proceeding, and employ evidence based arguments to show that *Homo sapiens* did not cause the extinction of *Homo neanderthalensis*. Students will investigate multiple lines of evidence, including fossil evidence, DNA, embryology, and anatomy. They will further use this evidence to construct explanations for common ancestry, adaptation, natural selection, and biological evolution. Students will research methods used in forensic anthropology to determine the age and origin of remain, and will learn

how these methods are used in modern court cases by determining the origin of remains found at a simulated crime scene.

Unit 3 - Key Assignments

1A: How and where did *Homo sapiens* evolve? Students collaborate to create a classroom chrono-atlas: a collection of maps of the world with fossil evidence of hominids. To do so, students will research the evidence of evolution (fossils, DNA, embryology, and anatomy) and create a group digital media presentation of fossil evidence, to explore the anatomy and DNA of a specific fossil, one of a variety of examples chosen by the teacher to demonstrate human fossils found around the world and from different times This atlas can be housed and used as a reference in the school library. Students will analyze the significant changes in traits observed on the chronoatlas, that have been selected for adaptations in the species over time by creating a model of the evolution of man within the geologic time scale. The students will use this analysis to write a caption/description for the atlas.

1B: In this assignment students will apply principles of evolution, natural selection, and viability/integrity of preserved evidence learned in the previous assignment. Students will write and present an opening statement for the defense in the court case Neanderthal v *Homo sapiens*, which charges the species Homo sapiens with mass murder and genocide, resulting in the extinction of the species *Homo neanderthalensis*. The teacher will assume the role of the prosecution, presenting a case charging Homo sapiens with these crimes. The teacher's case will include evidence from studies of 30,000 year old Neanderthal remains found with *Homo sapiens* bite marks. Students must create a defensive case which casts reasonable doubt on this assertion, using knowledge and research about how evidence loses its integrity over time, and principles of evolution and natural selection. Students will create a presentation to argue their case to a jury of their peers, other students who are not in the class.

2: Skeletal Records, A Bone to Pick

Students will apply what they have learned about the human body skeletal system to forensic anthropology. The students will be presented with a scenario where a construction project has encountered remains while excavating a building site. Students have a class discussion to identify the biological factors that can be determined on examination of bones, such as gender, age, stature, diet, etc. The students will jigsaw the factors and do a group research on how to determine their factor on remains. Students will collaborate as a class to create a key to use while examining remains. The students will study a variety of skeletal remains to identify origin as human/non-human. If human, the students will use the key created by the class to

identify the skeletal features to identify gender, age, and stature of the remains to create a report.

3: Can you Identify Ancestry?

The students will apply what they have used in learning human body skeletal and muscular systems to study how the bones of a human skull express inherited features from one generation to the next. The students will identify
how these anatomical features are found with greater frequency in certain populations; their presence or absence are clues to ancestry. Using skull diagrams, students will make observations of a skeleton by examining the morphology of the skull and by taking measurements of the skull cavity and face.
An unidentified skull was found around the Chesapeake Bay dating back to the 17th century. Students will make observations on this unknown skull and compare it to three main ancestral groups were represented around the Chesapeake Bay in the 17th century - American Indians, Europeans, and Africans from the sub-Saharan region. The students will write up their findings in a forensic lab report and use pictures and diagrams to explain their determination of the ancestry of the unknown skull using proof of anatomical features.

Unit 4 - Assault with a Deadly Weapon

Driving Question: How do ecological conditions affect the preservation of biological evidence?

In this unit students determine how varying ecological conditions affect the viability of biological evidence. Students compare and contrast the biotic and abiotic factors that exist in varying ecosystems, and try to predict how well evidence would last in these differing conditions. This includes the cycling of matter and energy through the environment by means of photosynthesis, cellular respiration, the water cycle, the nitrogen cycle, etc. Students will also examine and practice methods of forensic anthropology. Students design an experiment to test how unique environmental factors, such as climate, preserve ancient evidence. They further use this data to solve an ancient murder mystery. In this unit, students will explain the unique characteristics of Earth's various biomes and use this information to construct a model which illustrates how the ecology of each biome can affect the viability of evidence in a crime.

Unit 4 - Key Assignments

1: Ecological Influences on Biological Evidence

Students will be given a scenario of an assault with a deadly weapon involving a knife which can be disposed of in various environments. The students will research and design an experiment to test various simulated knives (multiple pieces of steel with identical “biological evidence” blood, fingerprint, and hair) in simulated biomes in the classroom that their group of four will create first. (Aquariums simulating the Rainforest,

Tundra, Desert, Freshwater, and Saltwater biomes.) Students will make daily observations of the evidence and note its apparent condition. These notes will be recorded in each student's field journal. Working from their knowledge of the Earth's various biomes, students will hypothesize which biome they believe would preserve the most biological evidence. Students will write a detailed hypotheses outlining the environmental and ecological conditions that they believe will contribute to the preservation and degradation of the biological evidence in each biomes. Each biome will be ranked for its perceived ability to preserve evidence. At the end of at least four weeks, the evidence will be removed and a final analysis will be done. Finally, students will write a paper describing their initial hypothesis, as compared to their field journal notes and the final analysis of the evidence.

2: King Tut: Natural Death or Murder?

In groups of 3-4, students will research the death of King Tutankhamun. Students will assume the role of a team of "detectives" assigned to investigate this ancient crime. Groups will be assigned a position to take on Tut's death - natural death or murder -- and half of the class should be assigned each position. Based on their research and their prior knowledge of forensic anthropology, each group will find evidence to support or refute their position on Tut's death. To do so, students must predict when environmental factors will result in stable ecosystems, and when environmental factors will lead to ecosystem change. Students will research the cycling of matter in the conditions present in the ecosystem in which the tomb was preserved. Students will also need to consider the ecological and environmental factors present that affect the evidence in formulating their hypotheses about the case.

Next, each group will submit a written "incident report" in the professional template to summarize their findings. Students must cite multiple sources of "evidence" and groups will explain why they believe that this evidence is still viable, including the environmental conditions that contribute to the viability of the evidence.

Finally, the groups will participate in a Congress style debate where the groups will present their case for the cause of King Tut's death. A panel of judges (teachers, administrators, industry experts) will decide the cause of Tut's death based on the information presented in the debate.

Unit 5 - Homicide

Driving Question: From crime scene to autopsy, what are the scientific processes used by crime scene investigators and forensic pathologists to investigate a homicide?

In this culminating unit, students will apply skills and knowledge from throughout the course to solve a homicide. They will learn and demonstrate how crime scenes are reconstructed by carefully documenting the conditions at a crime scene and recognizing all relevant physical evidence. Students will use their understanding of homeostasis to estimate time death in various scenarios. They will also examine the ecological role of insects in nutrient cycling and decomposition, and see how

entymology can be used to determine time of death. By the end of this unit, students will see first hand how the ability to recognize, collect, and break down evidence into manageable pieces, and then submit that evidence to physical and chemical testing is critical to both solving and prosecuting violent crimes.

Unit 5 - Key Assignments

1A: Estimating Time of Death

Students will be divided into groups of 3-4. Students will be working with knowledge gained in this unit about calculating time of death. Each group will be given a set of at least 5 different scenarios involving death. In each scenario a different amount of time will have passed since death. Groups will match up each scenario with the most accurate method of estimating time of death -- rigor mortis, livor mortis, algor mortis, decomposition, forensic entomology. Finally student groups will write up a paper outlining their reasons for selecting each specific method for determining time of death for each given scenario.

1B: Insects Role in Decomposition

Students will write a one page paper discussing the process of decomposition and the role that insects play in the decomposition process.

A laboratory activity observing the decomposition of a partial animal carcass will be conducted. A control sample will be allowed to decompose without insect intervention. A second carcass will have introduced dermestid beetle larvae. Students will make daily observations as to the growth, life cycle stage, and number of the dermestid beetles. They will also make observations as to the condition of the control sample carcass versus the carcass with introduced insects. Each of these observations will be recorded in the student's field journal.

Finally the students will write a paper in which they discuss their findings on the role that the insects played on the decomposition process. Students will also discuss how analyzing the life cycle of insects present could help to determine the estimated time of death. Their paper must support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

2: Animal Autopsy

This lab is adapted from a standard animal dissection combined with a post mortem report template to make an interesting way to introduce students to some of the general placements and relationships of many of the organs they will learn about over the course of the semester. Prior to this activity, students learn about the the eleven human body systems, body planes, regions, and directional terms used to describe the human body. Lab techniques will include measuring, weighing, mock toxicology testing and sketching of the organ placement in the body. Possible scenarios include, but are not limited to stabbing, gunshot, hanging, poisoning (through simulation via injection of dye into the esophagus) and fall from height. Students will assume the role of a forensic pathologist and use a professional template to go step by step to analyze the body and

propose the cause of death of the animal based on the evidence gathered from the autopsy.

3: Solve a Murder
Students will be expected to use skills and knowledge gained through the class curriculum to collect, process, and analyze evidence to solve a homicide. Students will work in investigation teams of 3 to 4 students on a homicide crime scene scenario set up in the classroom. They will document and identify evidence at the crime scene. The groups will have to demonstrate proper techniques by breaking down evidence collection into smaller, more manageable parts used to collect each item of evidence.

During their investigation, the students will have to identify what specific type of biological evidence they believe each piece of physical evidence will yield (DNA, fingerprints, hair, fibers). Students will have to use their knowledge of biological and biogeological processes to determine how to process the evidence, how to determine if the evidence if viable or if it has been corrupted, what tests they should run on the evidence, and how to analyze the results of the tests. Students will have to identify possible weapons which may have been used to commit the crime. Each group will identify the cause, method, or manner of death.

The information recorded will be documented in a summary report which will be reviewed/analyzed by their supervisor (Teacher).

Students will participate in a simulated trial where they must prepare and deliver expert testimony on the evidence collection and analysis. Students will be examined and cross-examined by the prosecution and defense, portrayed by industry partners. The teacher will evaluate each student's professional appearance, demeanor, and ability to answer questions clearly and accurately.

Course Materials:

Textbooks:
District Approved Biology Textbook
District Approved Earth Science Textbook
District Approved Forensic Science Textbook

Recommended Forensic Science Textbook
Title: Forensic Science Fundamentals & Investigations
Edition: 1st Edition
Publication Date: 2009
Publisher: South-Western Cengage Learning
Author: Anthony J. Bertino