ARIZONA STATE UNIVERSITY

GENERAL STUDIES COURSE PROPOSAL COVER FORM

Course information:

*Copy and paste **current** course information from Class Search/Course Catalog.*

Academic Unit: **College of Liberal Arts & Sciences** Department: **Chemistry & Biochemistry**

Subject: **CHM** Number: **194** Title: Crime Scene Science Units: 4

Is this a cross-listed course? (Choose one)
If yes, please identify course(s)

Is this a shared course? (choose one) If so, list all academic units offering this course
Course description:

Requested designation: Natural Sciences-SQ

*Note- a **separate** proposal is required for each designation requested*

Eligibility:

Permanent numbered courses must have completed the university's review and approval process.
For the rules governing approval of omnibus courses, contact the General Studies Program Office at (480) 965-0739.

Area(s) proposed course will serve:

A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study.

Checklists for general studies designations:

Complete and attach the appropriate checklist

- Literacy and Critical Inquiry core courses (L)
- Mathematics core courses (MA)
- Computer/statistics/quantitative applications core courses (CS)
- Humanities, Fine Arts and Design core courses (HU)
- Social and Behavioral Sciences core courses (SB)
- Natural Sciences core courses (SQ/SG)
- Global Awareness courses (G)
- Historical Awareness courses (H)
- Cultural Diversity in the United States courses (C)

A complete proposal should include:

- ☐ Signed General Studies Program Course Proposal Cover Form
- ☐ Criteria Checklist for the area
- ☐ Course Syllabus
- ☐ Table of Contents from the textbook, and/or lists of course materials

Contact information:

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Department Chair/Director approval: *(Required)*

Chair/Director name (Typed): Wilson A. Francisco Date: 09/30/2013

Chair/Director (Signature): Wilson A Francisco

Rev. 1/94, 4/95, 7/98, 4/00, 1/02, 10/08, 11/11/ 12/11, 7/12

Course Description - Short

Profesor Turnbough has been found dead in her office and it's up to students to determine what happened! Using what they learn about chemistry, physics, and biology, students in *Crime Scene Science* will examine the scientific evidence to help solve the mystery.

Crime Scene Science is an online survey course designed to serve the needs of undergraduate students and future K-8 teachers by helping them master basic concepts of science important in the world of forensic science, including the principles governing chemical reaction, force and motion, and the conversion of energy. In addition, this transdisciplinary course will help students understand concepts and develop skills that crosscut scientific disciplines, such as the ability to observe, think critically, measure, and gather and interpret data.

Course Description - Detailed

Crime Scene Science is an introductory course that will launch in Fall 2014. The course is oriented around a fictional narrative that involves the mysterious death of a professor and draws upon the popularity of crime fiction that showcases forensic science to engage students in the exploration of content and skills across a range of disciplines, including chemistry, biology, and physics.

This methodology was specifically chosen with three goals in mind. First, the course aims to alleviate widespread science anxiety among non-majors and preservice teachers by making learning about science as engaging as possible. Connecting the course to a fictional narrative disrupts students' traditional perception of science as dry and intimidating. This goal is particularly important with regards to preservice teachers. People tend to avoid that which they fear and/or don't understand and this dynamic has been especially devastating in K-6 science education, with some studies suggesting that many teachers spend less than an hour a week on science instruction. *Crime Scene Science* aims to quell science anxiety by presenting science concepts in fun, accessible, non-traditional ways.

Secondly, the course demonstrates to students the everyday relevance of science. Studies suggest that many students, particularly female students, disengage from STEM learning because they fail to see the social relevance of science. Such disengagement is ultimately detrimental to policymaking and global health. *Crime Scene Science* highlights how scientists apply seemingly abstract scientific concepts, such as thermodynamics or diffusion, in ways that have real-world consequences. Through the vehicle of forensic science, the course highlights how science contributes to social justice.

Finally, *Crime Scene Science* demonstrates how scientific disciplines are inextricably linked through principles that weave throughout the natural world and through practices that guide scientific inquiry. While the course guides students through investigations that emphasize content and skills in chemistry, physics, and biology, students come to understand that some concepts, such as energy transfer, transcend disciplinary boundaries and that ultimately a transdisciplinary approach is essential to understanding the "big picture." In addition, students recognize the central role the scientific method plays in scientific inquiry across the spectrum of disciplines. Throughout *Crime Scene Science* students make careful observations of the crime scene, gather evidence, analyze that evidence, and deduce the causes behind what they observe at the crime scene. The course begins with students encountering a crime scene and making observations of phenomena visible to the human eye. Students learn to apply scientific and mathematical skills that help them begin to make claims about observed phenomena. As the course progresses, students use mathematics and principles of chemistry and physics to make determinations about what, when, and how events at the “crime scene” unfolded. Finally, students drill down into microscopic investigations of biological identity markers, as well as the impact of chemical changes on the human system. As a result of these investigations, students come to understand science as a process that reduces uncertainty, rather than a dusty lexicon or canon of facts.

Besides content and skills mastery, *Crime Scene Science* aims to deepen students’ understanding of the nature of science. Unlike non-forensic scientists who often enjoy the ability to observe phenomena, forensic scientists must deduce explanations based on the analysis of evidence left behind at the scene. They therefore must be particularly sensitive to the degree to which uncertainty factors into their claims. *Crime Scene Science* students emerge from the course with an appreciation for the role uncertainty plays in in science and an understanding of science as an iterative process designed to reduce the unknown.

Crime Scene Science endeavors to bring real content and skills mastery in chemistry, physics, and biology to non-science majors and preservice teachers and to leave students with a broader appreciation for the vast scope and interrelated nature of scientific inquiry.

Natural Sciences [SQ/SG]

Proposer: Please complete the following sections and attach appropriate documentation.

ASU--[SQ] CRITERIA

I. - FOR ALL *QUANTITATIVE* [SQ] NATURAL SCIENCES CORE AREA COURSES, THE FOLLOWING ARE CRITICAL CRITERIA AND MUST BE MET:

YES	NO		Identify Documentation Submitted
☒	☐	**A.** Course emphasizes the mastery of basic scientific principles and concepts.	Criteria Justification, Detailed Syllabus
☒	☐	**B.** Addresses knowledge of scientific method.	Criteria Justification, Detailed Syllabus
☒	☐	**C.** Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	Criteria Justification, Detailed Syllabus
☒	☐	**D.** Addresses potential for uncertainty in scientific inquiry.	Criteria Justification, Detailed Syllabus
☒	☐	**E.** Illustrates the usefulness of mathematics in scientific description and reasoning.	Criteria Justification, Detailed Syllabus
☒	☐	**F.** Includes **weekly** laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	Criteria Justification, Detailed Syllabus
☒	☐	**G.** Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Criteria Justification, Detailed Syllabus
☒	☐	**H.** Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	Criteria Justification, Detailed Syllabus
II. - AT LEAST ONE OF THE FOLLOWING ADDITIONAL CRITERIA MUST BE MET WITHIN THE CONTEXT OF THE COURSE:			
☒	☐	**A.** Stresses understanding of the nature of basic scientific issues.	Criteria Justification, Detailed Syllabus
☒	☐	**B.** Develops appreciation of the scope and reality of limitations in scientific capabilities.	Criteria Justification, Detailed Syllabus
☐	☒	**C.** Discusses costs (time, human, financial) and risks of scientific inquiry.	

III. - [SQ] COURSES MUST ALSO MEET THESE ADDITIONAL CRITERIA:			
YES	NO		Identify Documentation Submitted
☒	☐	**A.** Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.	Criteria Justification, Detailed Syllabus
		B. Includes a college-level treatment of some of the following topics **(check all that apply below):**	Criteria Justification, Detailed Syllabus
☒	☐	**a.** Atomic and molecular structure	Criteria Justification, Detailed Syllabus
☐	☒	**b.** Electrical processes	
☒	☐	**c.** Chemical processes	Criteria Justification, Detailed Syllabus
☒	☐	**d.** Elementary thermodynamics	Criteria Justification, Detailed Syllabus
☐	☒	**e.** Electromagnetics	
☒	☐	**f.** Dynamics and mechanics	Criteria Justification, Detailed Syllabus

[SQ] REQUIREMENTS CANNOT BE MET BY COURSES:

- **Presenting a qualitative survey of a discipline.**
- **Focusing on the impact of science on social, economic, or environmental issues.**
- **Focusing on a specific or limiting but in-depth theme suitable for upper-division majors.**

Proposer: Please complete the following section and attach appropriate documentation.

ASU--[SG] CRITERIA			
I. - FOR ALL *GENERAL* [SG] NATURAL SCIENCES CORE AREA COURSES, THE FOLLOWING ARE CRITICAL CRITERIA AND MUST BE MET:			
YES	**NO**		**Identify Documentation Submitted**
☐	☐	**1.** Course emphasizes the mastery of basic scientific principles and concepts.	
☐	☐	**2.** Addresses knowledge of scientific method.	
☐	☐	**3.** Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	
☐	☐	**4.** Addresses potential for uncertainty in scientific inquiry.	
☐	☐	**5.** Illustrates the usefulness of mathematics in scientific description and reasoning.	
☐	☐	**6.** Includes **weekly** laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	
☐	☐	**7.** Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	
☐	☐	**8.** Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	
II. - AT LEAST ONE OF THE ADDITIONAL CRITERIA THAT MUST BE MET WITHIN THE CONTEXT OF THE COURSE:			
☐	☐	**A.** Stresses understanding of the nature of basic scientific issues.	
☐	☐	**B.** Develops appreciation of the scope and reality of limitations in scientific capabilities.	
☐	☐	**C.** Discusses costs (time, human, financial) and risks of scientific inquiry.	

[SG] REQUIREMENTS CANNOT BE MET BY COURSES:		
	• Presenting a qualitative survey of a discipline.	
	• Focusing on the impact of science on social, economic, or environmental issues.	
	• Focusing on a specific or limiting but in-depth theme suitable for upper-division majors.	

Course Prefix	Number	Title	Designation
CHM	194	Crime Scene Science	SQ

Explain in detail which student activities correspond to the specific designation criteria.
Please use the following organizer to explain how the criteria are met.

Criteria (from checksheet)	**How course meets spirit (contextualize specific examples in next column)**	**Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)**
		Designations in this column refer to the Detailed Syllabus (M=module)
I. A. Course emphasizes the mastery of basic scientific principles and concepts.	This course requires that students learn a number of fundamental scientific principles from a number of different fields/disciplines.	For example: M1 lecture topic: scientific method; M1 lab: Science Detectives, First Impressions M2 lecture topics: measurement, deductive logic; M2 readings M3 lecture topics: genetic variation, friction, waves; M3 readings M4 lecture topics: types of energy, mechanics, vectors, thermodynamics; M4 reading; M4 lab: Understanding projectile motion M5 lecture topics: scientific notation, types of chemical reactions, chemical equations/equilibrium; M5 labs: Chemical reaction types, The chemistry of cellular respiration M6 lecture topics: chemical structures; M6 lab: Identifying unknown substances from characteristic properties M7 lecture topics: uncertainty in science, inheritance of traits; M7 reading
B. Addresses knowledge of scientific method.	Use of the scientific method as a rigorous means of addressing scientific questions is a unifying theme in the course.	Scientific method is directly addressed in M1 lecture topics: scientific method, observation, hypotheses; M1 labs: Science Detectives, First impressions
C. Includes coverage of the	The course transcends a focus on	M2 readings; M2 lab: Footprint

methods of scientific inquiry that characterize the particular discipline.	narrow disciplinary methods to showcase how methods are used across disciplines. On the way to understanding, however, students encounter content and pathways of discovery considered central to a number of disciplines.	analysis; M3 readings; M4 readings; M4 lab: Understanding projectile motion M5 labs: Chemical reaction types and their equations; The chemistry of cellular respiration M6 lab: Identifying unknown substances from characteristic properties M7 lecture topic: Strengths and challenges of DNA fingerprinting; M7 reading
D. Address potential for uncertainty in scientific inquiry.	Various modules address the ongoing challenge of discussing degrees of uncertainty in the reporting of forensic data.	See for example: M2 lecture: What does the evidence allow us to claim?; M3 reading; M7 lecture topic: Strengths and challenges of DNA fingerprinting; 99.9999999%--What do numbers like thisr really mean?; Does your dog bite?; M7 reading
E. Illustrates the usefulness of mathematics in scientific description and reasoning.	The course directly addresses the importance of quantitative measurement in scientific description and reasoning.	See for example: M1 lecture topics: scientific notation, expressing data quantitatively; M2 lecture topics: measurement, probability; M2 readings; M3 lecture topics: friction; M3 reading; M4 lecture topics: mass and weight, velocity and acceleration; vectors; M4 lab: Understanding projectile motion; M5 lecture topics: scientific notation, chemical nomenclature, chemical equations; M5 lab: Chemical reaction types and their

		equations, The chemistry of cellular respiration; M7 reading
F. Includes weekly laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	The course includes weekly research explorations that include digital labs and manipulatives, as well as “do at home” laboratory activities.	All modules.
G. Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Students will be required to submit weekly lab reports that include statements of hypotheses, discussion of methods, analysis of data, and discussion of results.	All modules
H. Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	The course is a transdisciplinary survey that explores the varied disciplinary content and practices at the core of forensic investigation, including content and skills in chemistry, physics, and life science.	All modules, but see for example, the relationship between M4, M5, M6, and M7 whose lectures, readings, and labs shift students between basic concepts in physics, chemistry, and life science.
II.A. Stresses the understanding of the nature of basic scientific issues.	Students explore the nature of science and the process of scientific inquiry throughout the course. In addition, students engage foundational issues in science, including the transfer of energy, force and motion, genetic variation. The course also engages students in an exploration of issues that surround scientific inquiry, such as the role of bias and the challenge of communicating uncertainty.	See for example: M1 lecture topics: scientific method, cause and effect, role of bias; M1 lab: Science Detectives, First Impressions; M3 lecture topics: genetic variation; M3 readings; M4 lecture topics: thermodynamics, force and motion, energy transfer; M4 lab: Understanding projectile motion M5 lecture topics: energy transfer; M5 lab: Chemical reaction types; M6 lecture: pH; M6 lab: Acids, bases, and pH buffers M7 reading; M7 lab: DNA testing
B. Develops appreciation of the scope and reality of limitations in scientific capabilities.	The nature of forensic investigation, which requires scientists to reconstruct how an event transpired based on physical evidence, has natural limitations. Students examine how uncertainty and	See especially: M7 lecture topic: Strengths and challenges of DNA fingerprinting; M7 reading

	technology limit scientific capabilities.	
C. Discusses costs (time, human, financial) and risks of scientific inquiry.	Not a significant component of the course.	
III.A. Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.	*Crime Scene Science* introduces students to fundamental principles spanning chemistry, physics, and life science, including thermodynamics and chemical reaction.	See for example: M4 lecture topics: ballistics analysis; M4 lab: Understanding projectile motion; M5 lecture topics: scientific notation, moles, types of chemical reactions, energy transfer; M5 lab: Chemical reaction types
B. Includes college-level treatment of some of the following topics:		
a. Atomic and molecular structure	At various times in the course, students explore how scientists use physical changes in the body after death to draw conclusions about time of death. Such explorations necessitate an understanding of the nature of chemical reactions and the changes that occur in molecular structures.	M5 lecture topics: types of chemical reactions, rigor mortis, livor mortis; M5 lab: Chemical reaction types and their equations
b. Electrical processes	Not a significant component of the course.	
c. Chemical processes	Chemistry is central to a number of *Crime Scene Science* modules, especially in terms of understanding how energy is converted during chemical reactions and the role chemical reaction plays in the function and regulation of processes in the human body.	M5 lecture topics: types of chemical reactions, rigor mortis, livor mortis; M5 lab: Chemical reaction types and their equations; M6 lecture topics: chemical structures, diffusion; impact of drugs on the body; M6 labs: Identifying unknown substances from characteristic properties, Acids, bases, and pH buffers
d. Elementary thermodynamics	The course uses ballistics analysis and chemical investigation to teach students about different types of energy and how energy is transferred between weapon, bullet, and target, as well as between molecules in the cell.	M4 lecture topics: thermodynamics; M4 readings; M4 lab: Understanding projectile motion; M5 lecture topics: types of chemical reaction, M5 lab: Chemical reaction types, The chemistry of cellular respiration
e. Electromagnetics	Not a significant course component	
f. Dynamics and mechanics	The course uses ballistics analysis	M4 lecture topics: mass and weight,

	to teach basic concepts in mechanics including velocity, acceleration, and vectors.	velocity and acceleration, vectors: M4 readings; M4 labs: Understanding projectile motion, Angle of impact.

CRITERIA JUSTIFICATION

A. Course emphasizes the mastery of basic scientific principles and concepts.
Not a discrete body of content knowledge, forensic science is the practical application of science as it applies to the law. As such, forensic science is a wonderful vehicle for exploring a range of basic concepts in the natural sciences, especially concepts chemistry, physics, and the life sciences. While traditional forensic science courses might focus on procedural issues, this course uses forensic science as a springboard for explaining natural phenomena. Some of the basic principles that students will engage in the course include: the nature of science, types of chemical reactions, the conservation of matter, genetic variation, friction, wave properties, and forces and motion.

In contrast to traditional introductory science courses, *Crime Scene Science* focuses students not on a body of discipline-based concepts and skills, but on the transdisciplinary nature of scientific inquiry and the interconnectedness of the natural world. Additionally, as non-science majors, *Crime Scene Science* students arrive at an understanding of the social usefulness and real world relevance the process of science affords people hoping to solve problems and arrive at a deeper understanding of the natural world.

B. Addresses knowledge of scientific method.
One of the primary goals of *Crime Scene Science* is to introduce science as a dynamic process, guided not by a rigid, dusty set of rules, but by a methodology that facilitates discovery and elucidates fact from perception. The scientific method is integral to every module in the course.

Beginning in Module 1 and continuing throughout the course, students focus on the importance of careful observation. Using a combination of photographs and virtual environments, students conduct detailed observations of crime scenes and develop preliminary hypotheses based on their observations. In Module 2, for example, students observe and record measurements of footprints found at a crime scene. Students then conduct quantitative analysis of the footprints to deduce biometric information about the footprint's owner.

C. Includes coverage of the methods of scientific inquiry that characterize the particular discipline.
Crime Scene Science transcends a focus on narrow disciplinary methods to showcase how scientific methods are used across the disciplines. On the way to this understanding, however, students do encounter content considered central to a number of disciplines.

For example, one of the understandings students arrive at as they move through *Crime Scene Science* is role that chemical elements play in the various systems in the human body and how chemicals introduced into the body can impact the function of those systems. In its exploration of forensic chemistry, *Crime Scene Science* introduces students to one of the key principles in chemistry, that is, the conservation of matter and energy in chemical reactions. In Module 5, students model the chemical reactions at the core of cellular respiration and explore how the failure of the circulatory system in death causes physical phenomena such as algor mortis, livor mortis, and rigor mortis.

Crime Scene Science also incorporates elements of physics. In Module 4, students conduct observations and form hypotheses to explain the positioning of entry and exit wounds produced by a gunshot. Their investigations proceed to an exploration of basic concepts in physics, including mass and weight, velocity and acceleration, gravity, and energy transfer. From there, students are able to draw conclusions about the position of the perpetrator relative to the victim at the time of the injury.

Finally, *Crime Scene Science* also engages students in an exploration of genetic variation, adaptation, and evolution, concepts at the heart of modern biology. Students learn that genetic variation combined with environment produces unique fingerprints in humans to provide forensic scientists with a powerful biometric identity marker.

D. Addresses potential for uncertainty in scientific inquiry.
In their attempts to understand events after they have occurred, forensic scientists pursue three different threads of investigation: identification, individualization, and reconstruction. Beginning in Module 2, students learn that when forensic scientists focus on identifying the nature of a substance, they can make claims with high degrees of certainty (this substance is cyanide). In processes that focus on associating a particular piece of evidence with a particular source (individualization), forensic scientists operate in a realm of greater uncertainty and probability becomes a factor. Students learn that often forensic scientists speak of the likelihood of a certain event or they make claims that simply reduce levels of uncertainty. They often focus on excluding possibilities rather than claiming association. For example, that size 13 footprint was likely made by a male and was not produced by the shoe we have in our lab. In addition, students learn that science-based claims become more legitimate as the amount of evidence accumulates. This spectrum is also inherent in the notion of scientific theory, which is an explanation that has been repeatedly confirmed through observation and experimentation.

E. Illustrates the usefulness of mathematics in scientific description and reasoning.
To a significant degree, forensic investigation hinges on scientists' ability to identify and measure trace evidence. Throughout *Crime Scene Science*, students conduct measurements and are required to express their data quantitatively. Students conduct various calculations throughout the course, including (but not limited to): probability calculations in Module 2, calculations of friction and force in Module 3, graphing vectors in Module 4, and balancing chemical equations in Module 5. As the term *forensic* comes from the Latin word meaning "before the forum," the need for the public communication of scientific data is inherent in forensic investigation. Students will explore how the quantitative expression of data helps strengthen the claims scientists can make.

F. Includes weekly laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.
Beginning with the first module, this course stresses the components and importance of scientific methods. In weekly activities, students make observations, formulate hypotheses, and collect and analyze evidence. Taken together, the modules also compel students to revisit conclusions in light of new information/data, highlighting the iterative nature of scientific inquiry.

G. Students submit written reports of laboratory experiments for constructive evaluation by the instructor.
Students will be required to submit weekly lab reports that include statements of hypotheses, a discussion of methods, an analysis of data, and a discussion of results.

H. Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.
Crime Scene Science goes to great lengths to maintain the introductory and general nature of its content. The course is designed to highlight connections and build general, broad-based science literacy among non-majors. To that end, the course content has been chosen with an eye toward the Next Generation Science Standards--benchmarks for science literacy at the K-12 level which preservice teachers will need to master before entering the job market. While it isn't aligned to the standards (they would not be rigorous enough for undergraduate students), the course's topics relate to key content areas in the NGSS. This reinforces not only the relevance of the course for preservice teachers, but the foundational nature of the course content.

II. - AT LEAST ONE OF THE FOLLOWING ADDITIONAL CRITERIA MUST BE MET WITHIN THE CONTEXT OF THE COURSE:

A. Stresses understanding of the nature of basic scientific issues.
Crime Scene Science prompts students to explore and come to an understanding of basic scientific concepts and issues in a number of core science disciplines, including: the nature of science, chemical reaction, force and motion, genetic variation, and quantitative analysis. The course also engages students in an exploration of issues that surround scientific inquiry, such as the role of bias and the challenge of communicating uncertainty.

B. Develops appreciation of the scope and reality of limitations in scientific capabilities.

One of the persistent messages students encounter in *Crime Scene Science* is that scientists are bound by the availability of evidence and must deal with degrees of uncertainty in their efforts to determine the causes of natural phenomena. As much as forensic investigators would like to state with certainty that a crime transpired in a certain way, they are often compelled to make limited claims. Moreover, while technology is constantly improving, current technological capabilities often determine the degree of accuracy with which scientists can make claims. In Module 7, students learn about relatively recent technological developments that have enabled investigators to create a DNA fingerprint based on very small bits of evidence gathered at the crime scene. Despite this development, however, DNA fingerprinting remains challenging because of the difficulties in obtaining quality samples and because of ethical issues involved in keeping databases of DNA information.

C. Discusses costs (time, human, financial) and risks of scientific inquiry.
This criterion is not a key focus of the course.

III. - [SQ] COURSES MUST ALSO MEET THESE ADDITIONAL CRITERIA:

A. Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.
Crime Scene Science introduces students to fundamental principles in chemistry, physics, and the life sciences, including principles related to the behavior of matter and energy. The behavior of matter and energy in physical systems arises in a number of modules, but constitutes a core component of both Module 4, which uses ballistics to engage students in an exploration of thermodynamics, and Module 5, which focuses on energy in chemical reaction.

B. Includes a college-level treatment of some of the following topics (check all that apply below):
a. Atomic and molecular structure
Module 5 explores how scientists use physical changes in the body after death to draw conclusions about the time of death. In their study of rigor, algor, and livor mortis, students examine molecular structures and trace changes in molecular structures during chemical reactions.

b. Electrical processes
This criterion is not a key focus of the course.

c. Chemical processes
Chemistry is central to forensic investigation and is thus an important component in Crime Scene Science. In Modules 5 and 6, students examine chemical structures, the types of chemical reactions, the conservation of energy and matter in chemical reactions, the rate of reaction, and the role chemical reaction plays in the function and regulation of processes in the human body.

d. Elementary thermodynamics
Module 4 uses ballistic analysis to teach students basic thermodynamics. Students learn about the different types of energy and how energy is transferred between the weapon, bullet, and target. Students also encounter thermodynamics in Modules 5-6 which focus on chemical reactions. Labs in Module 5, for example, have students conduct investigations that highlight the

differences between synthetic, decomposition, single displacement, and double displacement reactions, as well as model the chemical reaction that occurs during cellular respiration.

e. Electromagnetics
Not a significant component of the course.

f. Dynamics and mechanics
Particularly in Module 4, which focuses on ballistic analysis, students in *Crime Scene Science* explore basic concepts in mechanics including velocity, acceleration, and vectors. Students use digital manipulatives to predict how varying initial conditions (angle, speed, mass, diameter, height, air resistance), affect a projectile's path.

CHEM194: Crime Scene Science
Fall 2014 Online

Module 1	It was a dark and stormy night… An Introduction to the crime scene
Objectives	Scientific method, usefulness of science, scientific notation

Topics	**Key Concepts**
Death and discovery of the crime scene	
Introduction to the course and the instructor	Overview of narrative structure of the course Overview of course objectives
What does a forensic scientist do?	Introduction to STEM career field Real world relevance of STEM careers Profile molecular biologist (Meredith) & toxicologist (chemistry)
Locard's Exchange Principle	Cause and effect
Scientific method and the nature of science	Nature of science Process of inquiry Importance of observation and testing
Observing the crime scene	Observation Hypotheses
Learning the language of science	Scientific notation Expressing data quantitatively

Readings, videos, podcasts, etc.	**Key Concepts**
Saferstein, Chap. 1: Introduction	Scope of forensic science

Lab 1	Science Detectives: Training Room Escape/ The Case of the Mystery Images

	Using an interactive digital game, students work through the process of observation and hypothesis formation
Lab 2	First Impressions: Observation
	Using a gigapan of the crime scene, students conduct and record their initial observations and develop a preliminary hypothesis as to the cause of death

Module 2	“The world is full of obvious things which nobody by any chance ever observes” : Observation and deduction
Objectives	Introduce scientific method and the nature of science, stressing importance of observation and measurement Introduce basics of quantitative analysis

Topics	**Key Concepts**
Orientation to the crime scene--What do I see and how do I see it?	Recording observations Wavelength and the electromagnetic spectrum Alternate light sources Examples of mistakes
What can footprints tell us?	Measurement Deductive logic
The cold hand of death: Algor mortis	Temperature Rates of change
Tear patterns	Observation Cause and effect
What does the evidence allow us to claim?	Uncertainty and probability
Case study: The guy who shot himself in the back of the head	Role of bias in observation

Readings, videos, podcasts, etc.	**Key Concepts**
Dingwall, H.L., Hatala, K.G., Wunderlich, R.E., and Richmond, B.G. (2013) Hominin stature, body mass, and walking speed estimates based on 1.5 million-year-old fossil footprints at Ileret, Kenya. *Journal of Human Evolution*, 64(6):556-68.	Quantitative analysis Measurement Human evolution

Alexander, R. M. (2006). Dinosaur Biomechanics. *Proceedings of the Royal Society*, v. 273, 1849-1855. http://rspb.royalsocietypublishing.org/content/273/1596/1849.full	Measurement Nature of Science Biomechanics Evolution/Adaptation
Saferstein, Chap. 2: The Crime Scene Saferstein, Chap. 3: Physical Evidence	Types of evidence Evidence collection

Lab	Footprint analysis
	Using materials readily available at home, students will measure and analyze footprints to make claims about the foot's owner.
Lab	Alternate light source investigation
	What a UV light (blacklight) can tell you at a crime scene and in your own home.
Lab	Algor mortis
	Using raw chicken breasts and thermometers, students design experiments to analyze how environment impacts the rates at which tissue cools.

Module 3	"Life is infinitely stranger than anything which the mind of man could invent": The strange world of fingerprints
Objectives	Use biometrics to explore concepts of genetic variation, force and motion, and waves.

Topics	**Key Concepts**
What are fingerprints?	Polymorphism Genetic variation and the role of the environment
Role of fingerprints	Friction Vibrations
A short history of fingerprinting	Biometrics Classification Historical evolution of science

Readings, videos, podcasts, etc.	**Key Concepts**
"Why do we have fingerprints?" *Science Friday* podcast, June 12, 2009, http://www.sciencefriday.com/segment/06/12/2009/why-do-we-have-fingerprints.html	Friction Nature of science
"The Role of Fingerprints in the Coding of Tactile Information Probed with a Biomimetic Sensor." J. Scheibert, S. Leurent, A. Prevost, and G. Debregeas (13 March 2009) Science 323 (5920), 1503	Vibrations
Jain, A., Prabhakar, S., Pankanti, S. (2002). On the similarity of identical twin fingerprints. *Pattern Recognition*, v. 35, 2653-2663. http://www.sciencedirect.com/science/article/pii/S0031320301002187	Biometrics Genetic variation
Saferstein, Chap. 16: Fingerprints	Historical evolution of science Probability

Lab	How much evidence is enough?: Virtual fingerprint lineup
	Students evaluate how many data points are needed for accurate comparisons between fingerprints.

Module 4	"Did you observe where the bullet went?" : Ballistics
Objectives	Use ballistic investigations to explore basic principles of thermodynamics and mechanics

Topics	**Key Concepts**
What are ballistics? interior ballistics exterior ballistics terminal ballistics	Thermodynamics Types of energy Energy transfer Mechanics Mass and weight Velocity and acceleration Gravity Drag
Entry and exit points	Vectors Energy transfer
Relative position	Angles Vectors
Ante-, peri-, or post-mortem?	Using evidence to construct a timeline

Readings, videos, podcasts, etc.	**Key Concepts**
Ballistic Movie Myth http://dsc.discovery.com/tv-shows/mythbusters/videos/mega-movie-myths-ballistics-breakthrough.htm	Energy transfer Real-world physics vs. special effects
Davidson, P.L., Taylor, M.C., Wilson, S.J., Walsh, K.A., & Kieser, J.A. (2012). Physical Components of Soft-Tissue Ballistic Wounding and Their Involvement in the Generation of Blood Backspatter. *Journal of Forensic Sciences*, v. 57, 1339-1342.	Mechanics Thermodynamics
Saferstein, Chap. 17: Firearms and tool marks	Chemical analysis (bullet composition, gunpowder residue, primer residue)

Lab	Understanding projectile motion
	Using an online manipulative, students predict how varying initial conditions (angle, speed, mass, diameter, height, air resistance), affect a projectile's path. http://phet.colorado.edu/en/simulation/projectile-motion
Lab	Angle of impact
	Evaluating relative position of shooter and victim.

Module 5	"It has long been an axiom of mine that the little things are infinitely the most important": The chemistry of death
Objectives	Analyze types of chemical reactions and the impact chemical reactions have on the body.

Topics	**Key Concepts**
Types of chemical reactions	Scientific notation Moles Chemical nomenclature Periodic table Synthetic, decomposition, single displacement, double displacement Balancing chemical equations
The Chemistry of Death: Rigor Mortis	Proteins Energy transfer Balancing chemical equations: Conservation of matter and energy Cellular respiration
Livor Mortis	Pressure Gravity

Readings, videos, podcasts, etc.	**Key Concepts**
What causes rigor mortis? The chemicals of life and rigor mortis Rigor mortis at the crime scene http://health.howstuffworks.com/diseases-conditions/death-dying/rigor-mortis-cause.htm	Biochemistry Estimating time of death

Lab	Chemical Reaction Types and Their Equations (Late Nite Labs)
	Students conduct investigations that highlight the differences between synthetic, decomposition, single displacement, and double displacement reactions.

Lab	Conservation of matter (Late Nite Labs)
	Students will investigate the Law of Conservation of Mass by studying two chemical reactions in closed systems. One reaction will take place entirely in solution, while the other will involve the generation of a gas product.
Lab	The chemistry of cellular respiration
	Students model the chemical reactions that occur during cellular respiration

Module 6	"I have a chemical analysis of some interest to finish" : Toxicology
Objectives	Analyze impact of chemical reactions on the function and regulation of the human body.

Topics	**Key Concepts**
What is toxicology?	pH Chemical structures
The impact of drugs on the body	Diffusion Metabolism
Drug detection methods	pH Separation of compounds Chromatography Technology and instrumentation

Readings, videos, podcasts, etc.	**Key Concepts**
Saferstein, Chap. 8: Drugs	Impact of chemicals on the human body
Saferstein, Chap. 9: Toxicology	Chromatography

Lab	Identifying Unknown Substances from Characteristic Properties (Late Nite Labs)
	Students analyze the extensive and intensive properties of substances to determine identity of unknown substances.
Lab	Acids, bases, and pH buffers (Late Nite Labs)
	Students measure the pH of various solutions using pH indicators and pH meters.

Module 7	"Data! Data! Data! I cannot make bricks without clay.": DNA fingerprinting and the role of technology in scientific inquiry
Objectives	Explore basic concepts of heredity Discuss complex relationship between technology and scientific inquiry.

Topics	**Key Concepts**
The strengths and challenges of DNA fingerprinting	Inheritance of traits Limitations in scientific capabilities Connection between technology and scientific inquiry
99.999999% - What do numbers like these really mean?	Data interpretation Probability
Does your dog bite? - The problems of getting the "right" answer to the wrong question	Results interpretation Prior odds

Readings, videos, podcasts, etc.	**Key Concepts**
Thompson, W. (2008). The Potential for Error in Forensic Testing. *GeneWatch*, v. 21, 5-8.	Scientific method Uncertainty in science Inheritance of traits
Saferstein, Chap. 11: DNA, the indispensable forensic science tool	Inheritance of traits Structure and function of DNA DNA testing

Lab	DNA testing (Late Nite Labs)
	Students conduct a paternity test to identify the biological father of a child. Students measure the size of the fragments by gel electrophoresis and then compare the results in an attempt to determine which of two men is the father.

SAMPLE STANDARD SYLLABUS

CHM194: Crime Scene Science (4 credits)
Syllabus, Fall 2014
Online course

4 credits
No pre-requisites
General Studies: Science Quantitative

Course Description
Profesor Turnbough has been found dead in her office and it's up to students to determine what happened! Using what they learn about chemistry, physics, and biology, students in *Crime Scene Science* will examine the scientific evidence to help solve the mystery.

Crime Scene Science is an online survey course designed to serve the needs of undergraduate students and future K8 teachers by helping them master basic concepts of science important in the world of forensic science, including the principles governing chemical reaction, force and motion, and the conversion of energy. In addition, this transdisciplinary course will help students understand concepts and develop skills that crosscut scientific disciplines, such as the ability to observe, think critically, measure, and gather and interpret data.

Instructor:
Meredith Turnbough, Assistant Research Professor, College of Liberal Arts and Sciences
Office: CPCOM 313
Email: meredith.turnbough@asu.edu

Additional course developers:
Wilson Francisco, Associate Chair and Professor, Department of Chemistry & Biochemistry

Course goals:
This course aims to strengthen students' understanding of science as a process of inquiry involving careful observation, accurate measurement, controlled experimentation, reasoned interpretation, and lucid communication of results. The course also aims to strengthen students' grasp of science content in chemistry, physics, and life science, with the goal of building science literacy among non-science major undergraduates in general, and prospective elementary and middle school teachers in particular. This course focuses not on the procedures used in forensic science, but rather the science behind forensic inquiry.

Course objectives:

1. Show how the scientific method is used within and beyond the sciences for problem solving and develop skills competency relevant to scientific inquiry, including:
    a. The ability to analyze and interpret data using tools such as tables, charts, and graphs and to summarize and display data;
    b. The ability to recognize dimensional qualities and use appropriate units in scientific applications of mathematical formulae and graphs.

2. Introduce students to basic concepts in chemistry, physics, and life science in an integrative manner through the vehicle of forensic science, including the principles governing:
    a. Chemical reaction
    b. The structure and function of molecules
    c. The conversion of energy
    d. Force and motion
    e. Inheritance of traits

3. Introduce students to the concept of deductive logic and explore its role in scientific inquiry generally, and forensic science, in particular.

4. Introduce students to the role of uncertainty in science and the limitations of scientific inquiry. Along the way to this understanding, students develop an understanding of interrelationship between science and technology, particularly as it relates to the role instrumentation and information technologies play in scientific inquiry.

Student learning objectives:
After taking this course, students will be able to:
1. Use the scientific method to solve problems.
2. Understand the importance of observation and measurement
3. Understand the nature of science and the role of uncertainty and probability.
4. Understand the role of bias in scientific inquiry.
5. Describe Locard's Exchange Principle and the concept of cause and effect.
6. Understand the types of chemical reactions and their centrality to the function of the human body and be able to use the language of chemistry to express the nature of substances and reactions.
7. Quantitatively express basic physical science concepts, including mass and weight, velocity and acceleration, gravity, vectors, diffusion, and thermodynamics.
8. Understand basic concepts in the life science, including the inheritance and variation of traits.

Assignments and grading:

Required materials and activities:
Saferstein, *Criminalistics: An Introduction to Forensic Science*, 10th edition (Prentice Hall, 2011)

Besides the textbook, students will access course content via a series of weekly course readings, videos, powerpoint presentations, and scientific simulations posted on the course homepage in the course management system.

Lectures, Labs, and Investigative Assignments

Module 1: It was a dark and stormy night… An introduction to the crime scene

Topics:
- Course Introduction--Death and discovery of the crime scene
- Introduction to the field of forensic science
- What does a forensic scientist do? (science as problem-solving)
- Locard's principle--cause and effect, contamination of crime scene
- Scientific method
- Observing the crime scene
- Understanding the scientific method and the nature of science
- Learning the language of science

Lab 1: Science Detectives: Training Room Escape/Case of the Mystery Images
Lab 2: First impressions: Observation

Module 2: “The world is full of obvious things which nobody by any chance ever observes”: Observation and Deduction

Topics:
- Orientation to the crime scene
- What can footprints tell us?
- The cold hand of death: Algor mortis
- Tear patterns
- What does the evidence allow us to claim? (uncertainty and probability)
- Conducting and recording observations
- Case study: Role of bias in observation

Lab: Footprint analysis
Lab: Alternate light source investigation
Lab: Algor mortis experiment

Module 3: “Life is infinitely stranger than anything which the mind of man could invent”: The Strange World of Fingerprints

Topics:
- What are fingerprints? (genetic variation and the role of the environment)
- Role of fingerprints (friction, sensitivity)
- A short history of fingerprinting (biometrics)

Lab: How much evidence is enough?: Virtual fingerprint lineup

Module 4 “Did you observe where the bullet went?”: Ballistics

Topics:
- What are ballistics? Interior, exterior, terminal ballistics
- Entry and exit points (thermodynamics, force and motion)
- Relative position (angles, vectors)
- Ante-, peri-, or postmortem?

Lab: Understanding projectile motion
Lab: Angle of impact

Module 5: “It has long been an axiom of mine that the little things are infinitely the most important”: The Chemistry of Death

Topics:
- Types of chemical reactions (scientific notation, moles, chemical nomenclature, periodic table, balancing chemical equations)
- The chemistry of death: Rigor mortis (proteins, energy transfer, cellular respiration)
- Livor mortis (pressure, gravity)

Lab: Chemical reactions: Types and their equations
Lab: Conservation of mass
Lab: Chemistry of cellular respiration

Module 6: "I have a chemical analysis of some interest to finish": Toxicology

Topics:
- What is toxicology? (pH, chemical structures)
- Impact of drugs on the body (diffusion, metabolism)
- Drug detection methods (pH, separation of compounds, chromatography, technology and instrumentation)

Lab: Identifying unknown substances from characteristic properties

Lab: Acids, bases, and pH buffers

Module 7 "Data! Data! Data!...I can't make bricks without clay.": DNA fingerprinting and the role of technology in scientific inquiry

Topics:
- Strengths and challenges of DNA fingerprinting (inheritance of traits, limitations of scientific capabilities)
- 99.9999999%--What do numbers like these really mean? (data interpretation, probability)
- Does your dog bit?--The problems of getting the 'right' answer to the wrong question

Lab: DNA testing

Richard Saferstein, *Criminalistics: An Introduction to Forensic Science*, 10th edition (Prentice Hall, 2010)

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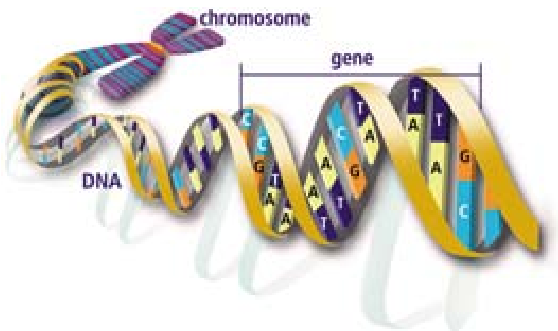
Background

Each living organism's genetic blueprint emanates from its Deoxyribonucleic Acid (DNA). DNA is made of two strands of nucleotides wound together in a spiral – called a double helix – that resembles a twisted ladder, as in the image below.



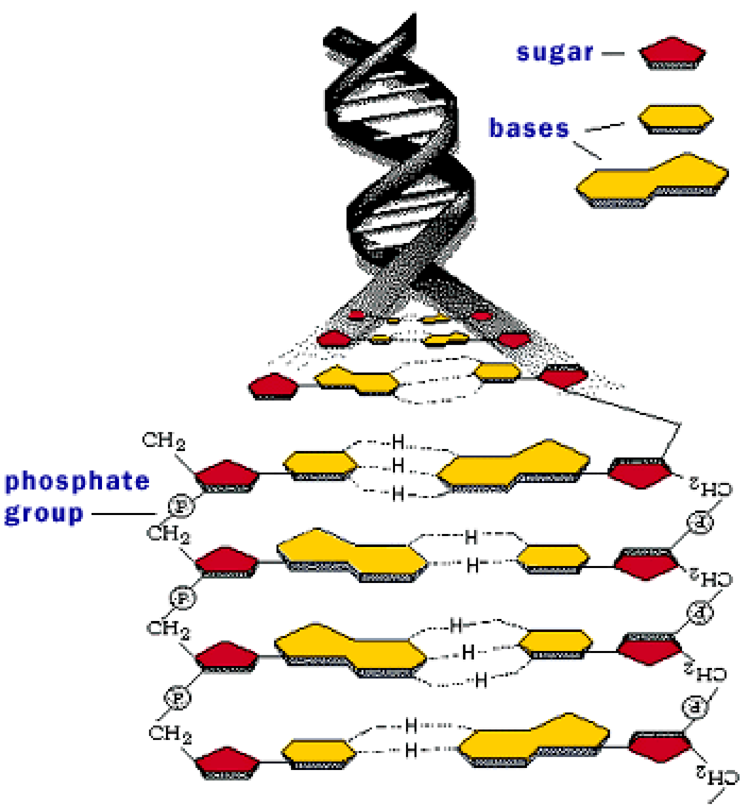
In this lab you will conduct a paternity test to identify the biological father of a child. The DNA samples provided have already been cut and amplified by PCR to yield fragments that are from two distinct and inherited alleles. Samples are available from the child, its known mother, and two men thought to be possible fathers

You will measure the size of the fragments by gel electrophoresis and then compare the results in an attempt to determine which of the two men is the father.

DNA Structure

The two long strands forming the sides of the ladder are the backbone. They are made of alternating sugar (the 5-carbon deoxyribose) and phosphate molecules.

The rungs of the ladder are composed of two nitrogenous bases that are linked by hydrogen bonds. There are four possible bases: adenine, thymine, guanine, and cytosine, denoted in shorthand form as A, T, G, and C. Each rung of the DNA ladder contains one pair of bases, and the length of any DNA strand or fragment is measured in number of *base-pairs* (or *bp*).



The structure of DNA can also be understood as a collection of nucleotide pairs that combine to form a long, twisted structure of the double helix. A nucleotide is defined as one sugar molecule bonded to a phosphate molecule and a nitrogenous base. Nucleotides combine to form long strands by strong bonds between the sugar and phosphate molecules, and then the individual strands are joined by weaker hydrogen bonds between each pair of bases.

The bases on each rung of the resulting DNA ladder double helix follow the Base-Pairing Rule:

- nucleotides with base A will pair up with nucleotides that have base T
- nucleotides that have base G will pair with nucleotides that have base C

This Base-Pairing Rule makes it easy to copy DNA by pulling apart the two halves of the ladder. Then each half can be made whole again by building up the empty side with its complementary pairing.

Genetic information is contained in certain segments of the DNA molecule - our genes. These segments vary in their number of base-pairs, from just a few dozen to several thousand. That variety gives each gene the unique ability to code for specific characteristics of the organism.

Human DNA is some three billion base pairs long, thought to contain 20,000 to 25,000 genes, although the non-coding portions (so-called "junk DNA") continues to yield more genetic information.

Methods Used to Study DNA

In order to study DNA base pairs and sequences, scientists first use special *restriction enzymes* to cut the DNA molecule at specific restriction sites. A restriction site is a sequence of bases recognized by the enzyme; recall that enzymes match up with substrate molecules in a lock and key pattern. �

There are many different kinds of restriction enzymes. Each restriction enzyme will only cut DNA at the specific sequence of bases that it recognizes. For example, the restriction enzyme SmaI cuts DNA only when it recognizes the base sequence CCCGGG. Another example is the restriction enzyme EcoRI, which cuts DNA only at the base sequence GAATTC. �

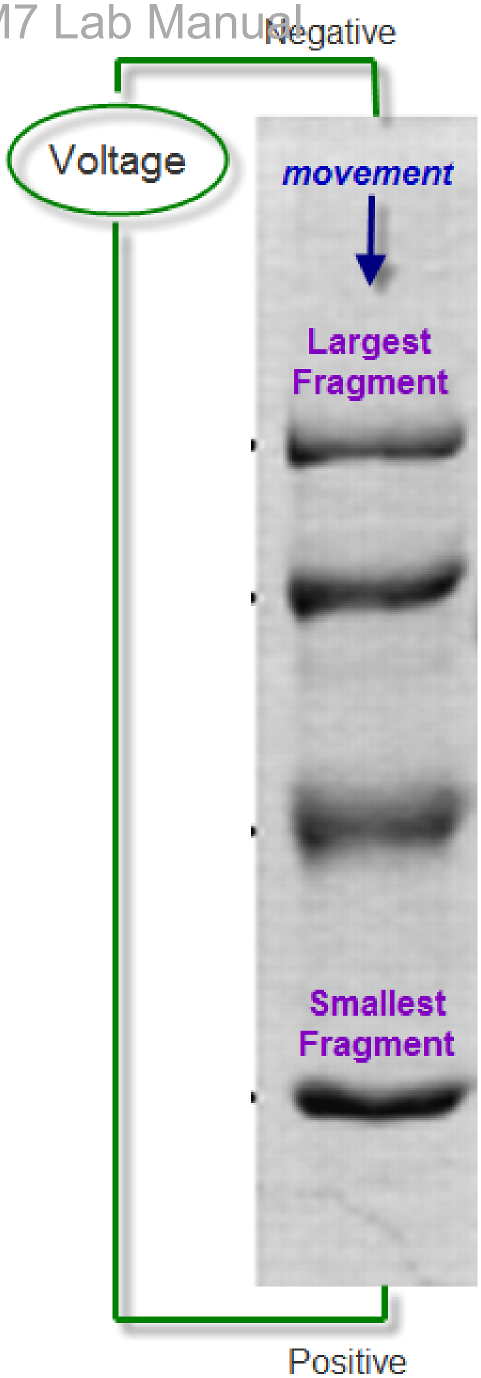
The fragments cut from a sample of DNA using a restriction enzyme can then be separated and sorted by size during a process called *gel electrophoresis*.

Electrophoresis

The Gel is the filter that sorts DNA fragments by size. It is a hard, rubbery slab made by dissolving agarose in water and letting it cool, similar in process and appearance to jello prepared in a rectangular tin pan. The gel slab acts like a sponge, in that it has many small holes and channels in it. DNA samples are deposited in holes, or wells, at one end of the gel.

Electrophoresis is the process of running an electric current through the length of the gel. An electrical voltage is applied to the gel containing the DNA and, because DNA is negatively charged, the DNA is attracted to the positive end of the electric field. The fragments are effectively pushed by the current from the end of the gel where they were deposited to the opposite end.

The key to this analytical technique is that DNA fragments travel at a rate inversely proportional to their size. Smaller fragments migrate through the gel quickly while longer fragments migrate more slowly, thereby creating a pattern of fragments neatly arranged from smallest to largest in size.In this way, the DNA fragments in the sample are sorted according to size as seen below.



Note that gel electrophoresis is useful in separating other sets of molecules by size, such as proteins, chlorophyll molecules, and color pigments.

DNA Profiling

DNA profiling is a genetic testing technique that compares different samples of DNA to see how well they match. For example, it could be used to compare DNA samples from a father, mother, and child. Forensic scientists also use this method to analyze DNA collected from a crime scene to assist in identifying potential suspects.

DNA profiling is made possible by the following characteristics of human DNA across entire populations:

- Restriction Enzymes – Specific sequences of base pairs along a strand of DNA can be cut with restriction enzymes and then amplified by polymerase chain reaction (PCR) to obtain thousands or millions of copies of the single fragment. That fragment's size can then be measured by gel electrophoresis. All of the copies of one fragment will show up as one band on the gel. �
- Variable Number Tandem Repeats – The size of a fragment cut from DNA is highly variable among the human population. This variability is largely due to the presence of repeating base pair sequences that occur all along the DNA molecule. These repeating sequences, called VNTR's (variable number tandem repeats), currently have no known genetic function, but since the likelihood of

any two individuals having the same length of VNTR's is so astronomically small, they can be used to identify individuals, as with forensic analysis.

- Rules of Inheritance – Fragments that contain one or more alleles follow the rules of inheritance:
  1) There will be one fragment size inherited from each parent because the fragment must come from both pairs of chromosomes. Even allowing for a small number of mutations from generation to generation, the child's DNA fragments will be almost identical in length to one fragment from each parent.
  2) If the fragments contain one or more VNTR's, then the size of these fragments is expected to be unique to each parent. It should then be possible to identify from which parent a child inherits each allele.

Research continues to identify combinations of restriction enzymes, PCR techniques, and VNTR locations, along human DNA, to come up with the most reliable identification methods.

Procedures

In this lab, you're investigating this scenario: The identity of Kim's biological father is unknown. Her mother, Rachel, believes him to be either Kevin or Thomas. To determine paternity, blood typing was performed for all four individuals.

Here are the results of the blood tests, including the phenotypes and possible genotypes of each person:

Blood Test Results			
Name	**Relationship**	**Blood Type**	**Genotype**
Rachel	Mother	AB	IA, IB
Kim	Child	A	either IA, IA if homozygous, or IA, i if heterozygous
Kevin	Alleged Father #1	A	either IA, IA if homozygous, or IA, i if heterozygous
Thomas	Alleged Father #2	O	ii

Given these blood types, neither Kevin nor Thomas can be ruled out as Kim's father. Further testing is necessary, so you'll perform the DNA profiling test with gel electrophoresis.

Cheek swabs were taken from each subject and processed to extract DNA, all of which were then treated with the same restriction enzymes that cut fragments at the same loci. The fragments were then amplified by PCR to generate thousands of copies, and these DNA samples are ready to be analyzed by gel electrophoresis.

Note:

A gel electrophoresis system has been prepared for you and placed on the Instruments shelf. The system is composed of a plastic chamber with a gel slab lying in it and a power supply with leads connected to the two ends of the chamber.
The negative lead is connected to the side of the gel where the wells are located. This is where the DNA samples are inserted. The positive lead is connected to the opposite end and the DNA fragments are drawn toward it.
In order to complete the electric circuit, an electrolyte buffer must be poured into the chamber, covering the gel and contacting the leads at either end. One typical electrophoresis buffer is a solution of Tris-borate-EDTA, abbreviated as TBE .

Part 1: Loading the DNA Samples into the Gel

1. Place the Electrophoresis Chamber from the Instruments shelf onto the workbench.

2. Place an Erlenmeyer flask from the Containers shelf onto the workbench.

3. Add 100 mL of TBE loading buffer from the Materials shelf to the flask.

4. Move the flask onto the electrophoresis chamber. Pour all 100 mL of the TBE loading buffer into the chamber.

5. Place five microtubes and a micropipette from the Containers shelf onto the workbench.

6. Fill your microtubes according to the chart below.

Microtube Set-ups		
Tube	**DNA Sample**	**Amount in Tube (mL)**
1	DNA Ladder	1
2	Mother's	1
3	Child's	1
4	Alleged Father #1 (A.F. #1)	1
5	Alleged Father #2 (A.F. #2)	1

Note: The DNA LADDER contains DNA fragments of known lengths. Running it on the gel will give you a reference by which to estimate the lengths of the DNA fragments in your samples.

For each microtube:

- double-click on the microtube to label it.
- add the designated DNA sample from the Materials shelf into the microtube.

7. Set-up the Electrophoresis Chamber according to the chart below.

Electrophoresis Chamber Set-ups			
Tube	**DNA Sample**	**Amount in Micropipette (µL)**	**Lane**
1	DNA Ladder	5	1
2	Mother's	5	2
3	Child's	5	3
4	A.F. #1	5	4
5	A.F. #2	5	5

For each sample being tested:

- move the micropipette onto tube
- draw the designated 5 µL. Observe the plunger at the top of the micropipette moving.
  The micropipette comes with a clean disposable pipette tip already attached, which automatically switches each time you use the pipette to prevent contamination.
- Move the micropipette onto the Electrophoresis Chamber. Select the lane specified in the chart in the pop-up that appears.

8. In your notes, record the identity of the DNA samples placed in each lane.

Part 2: Running the Gel

1. Turn the dial of the Electrophoresis Chamber's power supply to set the voltage to run it on these settings:
   - 350 volts

   Press on the power supply to begin.

2. Start a timer by clicking on the clock icon in the lower left corner of the lab.

3. Run the gel for 15 minutes and then turn the power supply off.
   The amount of time you run this gel will affect your results. If you run it for too long you will lose fragments from your ladder and not be able to identify the size of your fragment.

Part 3: Analyzing the Results

1. Place a UV Viewer from the Instruments shelf onto the workbench.
   Note: In order to see the bands of DNA fragments, the gel must be soaked in a dye that binds to the DNA and is then rinsed off. In this lab, that step is automatically done for you using ethidium bromide (EtBr), which binds to DNA and shines brightly under ultraviolet (UV) light.

2. Move the gel from the Electrophoresis Chamber by clicking on it and moving the gel onto the UV Viewer. You should observe

bright lines, called "bands", in columns running downward from each well in which you placed a DNA sample.

3. Use the navigation controls in the lower right of the lab to zoom in on the UV Viewer.

4. Compare your fragments with the ladder in order to determine their size.
   The DNA Ladder in Lane 1 has fragments of the different sizes, in units of kilo-base pairs (kb). You should see 13 bands in Lane 1:
   - 50 bp
   - 100 bp
   - 150 bp
   - 200 bp
   - 250 bp
   - 300 bp
   - 400 bp
   - 500 bp
   - 600 bp
   - 700 bp
   - 800 bp
   - 900 bp
   - 1,000 bp

   To read the bp of each band, hover your cursor over it.

5. Use the ruler at the left of the UV Viewer to measure the distance from the wells to each band of the DNA ladder (in mm). Record the distance along with its size in bp units, in your lab notes.

6. Now measure the distance traveled by each band in Lanes 2 through 5.
   Given that we are dealing with fragments from one allele, there should be two bands in each lane. Record in your lab notes the position of each band.

7. Estimate the size of the fragments in the band by noting its position relative to the DNA Ladder. Try to estimate fragment size within 10 or 20 bp. Be sure to save your notes.

Something Practical: More Than Four - Testing 5,000!

In the 1980's, Colin Pitchfork was the first criminal to be convicted of murder by DNA evidence. He was identified by wide scale testing of 5000 men.

Two 15-year-old girls were raped and killed in England in 1983 and 1985. A suspect was almost convicted, but new DNA profiling demonstrated that his DNA wasn't a match for semen samples collected from the victims. Five-thousand local men were asked to give blood or saliva samples. After six months of testing, no match was found. Pitchfork had paid a friend to give a DNA sample in Pitchfork's place. Luckily, that friend was overheard bragging about the easy money.

Pitchfork was arrested, a sample of his DNA taken and found to be a match. He was convicted and sentenced to life in prison.

Notes