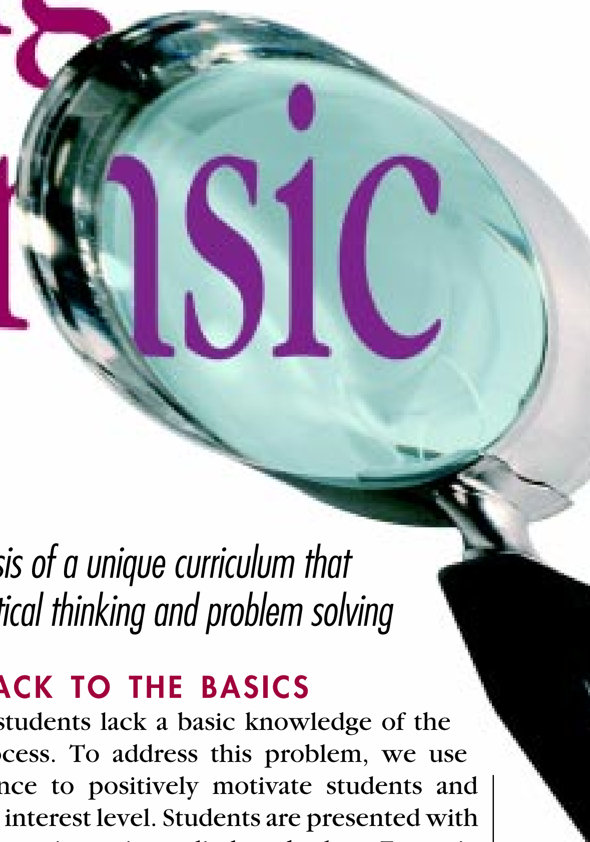
Integrating Forensic Science



Forensics can be the basis of a unique curriculum that fosters analytical thinking and problem solving

FOR THE PAST TWO DECADES OR SO, TELE-vision shows, books, and movies that portray detective work and forensic science have become increasingly popular. Although these portrayals are not always accurate, they demonstrate that science is an important tool in answering difficult questions. Forensic science is appealing to many people because they want to be "detectives" in the general sense and solve problems and puzzles. This has resulted in an explosion of interest, especially among high school and college students and teachers, in the study of forensic science.

This unprecedented interest in forensic science makes it an effective mechanism for teaching integrated science, and the nature of forensic science makes it ideal for attacking the problems of teaching science because students can practice science as inquiry. The *National Science Education Standards* emphasizes the need for students to become proficient at critical thinking and problem solving. To accomplish these goals, educators must develop in students the necessary skills and confidence. The Standards states, "processes of science require that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science" (National Research Council, 1996, 105).

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BACK TO THE BASICS

High school students lack a basic knowledge of the scientific process. To address this problem, we use forensic science to positively motivate students and increase their interest level. Students are presented with aspects of how science is applied to the law. Forensic principles are introduced, and students participate in inquiry activities for each topic, culminating with a mock crime scene. The scene is strewn with evidence that students are expected to observe, collect, analyze, and evaluate to determine its significance. To every piece of physical evidence analyzed, students must apply the scientific method (observation, questioning, collecting and classifying data, looking for relationships, forming a hypothesis, and testing the hypothesis) and then advance a conclusion or opinion as to what happened at the scene and who committed the crime. Students must then be prepared to defend conclusions based on their own empirical evidence.

Some of the advantages of this approach are:

- Forensic science is multidisciplinary (Figure 1). It embodies concepts in many areas including biology, chemistry, zoology, anatomy, genetics, physics, medicine, math and statistics, Earth science, sociology, psychology, communications, and law.
- Forensic science lessons can integrate various sciences to solve a specific problem, which in most cases is a crime.
- Forensic science appeals to the natural detective in people and also to those who like to solve puzzles.

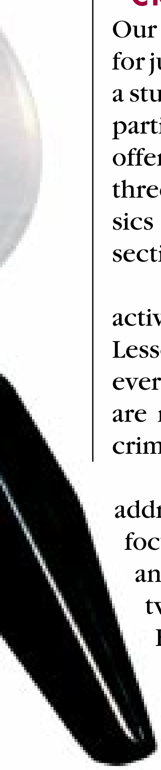
■ Forensic science is suitable for all ages. Some concepts, such as the classification of fingerprint types, can be introduced as early as primary school. This allows young children to be taught how to think critically and solve problems and how science can be useful and enjoyable.

Our ultimate goal is for students to make sense of complex problems that require logical reasoning and involve numerical data, evidence, and uncertainty.

CRIME ANALYSIS IN THE CLASSROOM

Our high school course began as a one-semester course for juniors and seniors in a typical urban high school with a student population of about 1700. Student interest and participation was so high that the following year we offered two sections of a yearlong course. Since then, three more local high schools have picked up the forensics curriculum, and yet another high school will start a section next year.

Figure 2 lists the course syllabus. As with most activity-driven courses, block scheduling is advantageous. Lessons (units) integrate the sciences by applying whatever knowledge and skills are necessary to solve a crime.



Each of the lessons addresses an individual focus of forensic science and is intended to take two to three weeks. For instance, the unit on fibers is primarily chemistry-based; however, other sciences are required for characterization of evidence as well as assessment of its forensic value. Scientific principles taught in this unit include the properties of light, studied in the determination of refractive index (physics); statistics, used to assess the probability of a fiber link between suspect and victim (math); and microscopic observation, used to differentiate natural and synthetic fibers (biology).

In this unit, we focus on polymers because more than half of all fibers are now synthetic. A teacher demonstration of the preparation of nylon is pertinent, as is a laboratory activity in which students prepare polyester from phthalic anhydride and ethylene glycol. Students examine the effects of cross-linking by substituting glycerol for ethylene glycol and then classify and compare fibers through chemical tests such as combustion, thermal decomposition, and chemical reactivity. The subject of dyes and dyeing can be introduced, and thin layer chromatography can be used to compare dyes of a colored fiber.

In the fibers unit, we explain to students that fibers are only one clue that may be found at a crime scene. The presence of fibers may be considered trace evidence, the value of which lies in creating connections or associations among victims, suspects, and places. Most trace evidence is not unique to an individual, as are fingerprints; therefore, comparisons must be based on as many similarities as possible. Statistics and probability are introduced in this unit, as they are in most exercises, to assess possibilities.

Another biology-based unit is on hair. This unit requires a compound microscope to observe and characterize different types of human and animal hair as well as

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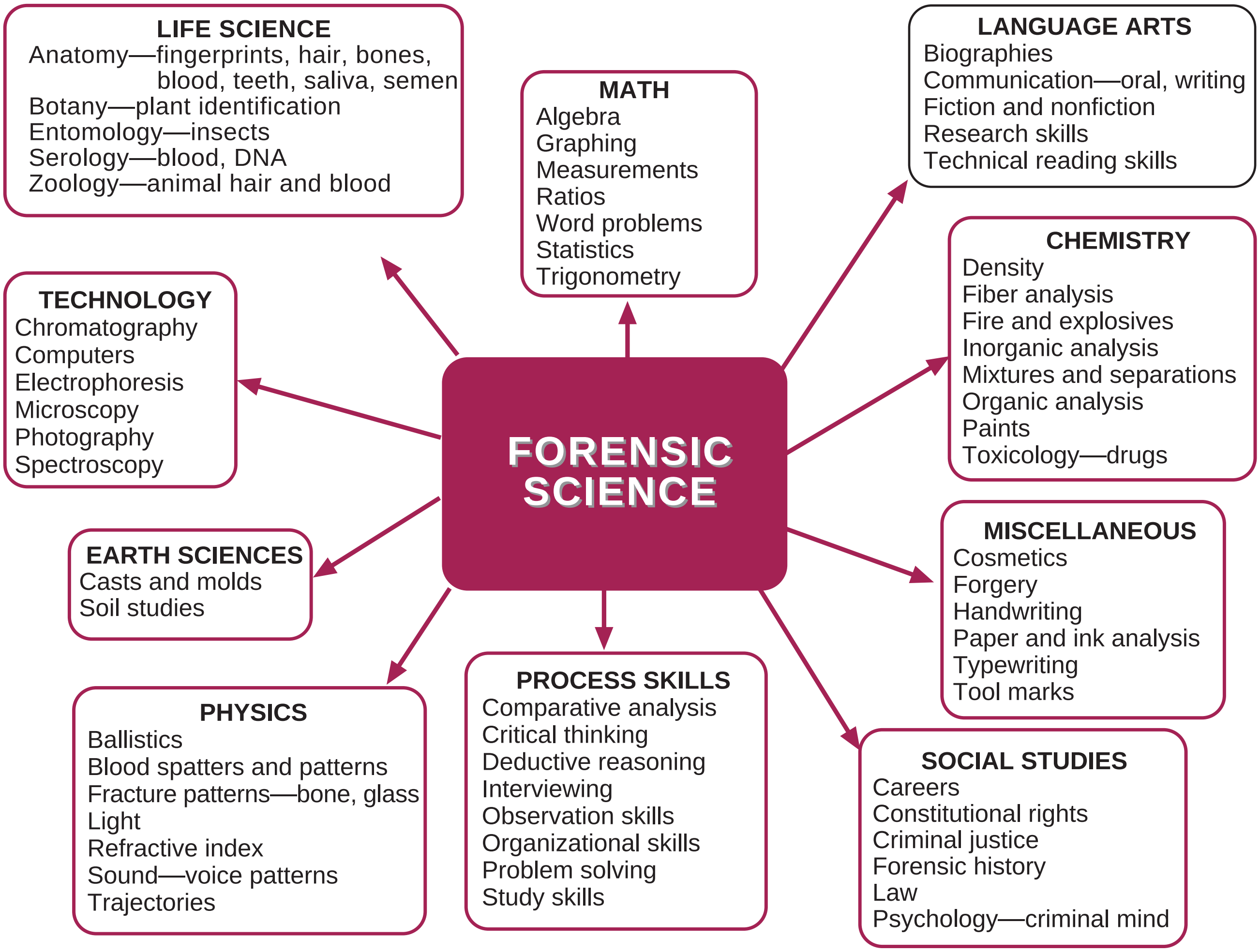
FIGURE 1.

Disciplines and tools of forensic science.



note the effects of hair treatment. Integrated into the lesson are physics and chemistry. Physics is used to determine the diameter of a hair sample. To do so, students measure the distance between bright spots of interference patterns on hair, using a laser pointer, some cardboard, and a ruler. (Students doing this exercise must be cautioned not to look directly into the beam.) This exercise demonstrates the wave nature of light. Many of the properties of hair are related to the chemical composition and structure of polymeric proteins. This can lead to further discussion and investigation of natural polymers, including DNA.

Approaching science from an application point of view allows many avenues of exploration, encompassing many disciplines. For example, hair can collect substances ingested by the body, and many drugs, drug metabolites, vitamins, and poisons can be detected by sophisticated analytical techniques. Students can do research projects investigating the legal aspects of taking hair samples from a suspect or employee, the effect of hair treatment in the detection of drugs and poisons, or the efficacy of using hair analysis as a diagnostic tool in medicine and environmental science. DNA analysis can be performed on the hair root or tissue attached to the hair, which opens up new aspects of investigation for research projects.

Another unit, soil analysis, focuses on Earth science principles as well as chemistry and physics. Using as many properties as possible to characterize and match soil samples, students make macro- and microscopic observations of overall color, particle and density distribution, pH, and rate of settling. One crime scenario we present can only be solved by interpreting a topographic map with respect to relating soil evidence to a location, such as a swamp.

Serology, the focus of another unit, incorporates both biology and physics. Biological principles are used to determine whether or not a particular stain is blood, if it is from a human or animal, and the blood type. Physics principles are used in analyzing blood spatter patterns, measuring the angle of impact, finding the velocity at which the blood hit the object on which it spattered, measuring the distance from which the blood was dropped, and finding the direction from which it spattered. The application of trigonometry is important.

Each unit is activity-driven and inquiry-based. Students are encouraged to ask questions and then begin, usually in a collaborative way, to answer them. For example, in the fingerprints unit, groups of students study their fingerprints and try to find a means of describing and classifying them. Only after each group has reported their findings, and common characteristics are defined, are the basic classical patterns presented. Simple statistics can be gathered to determine what percentage of the class's fingerprints contain loops, arches, and whorls.

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EXTENSIONS AND OBSTACLES

Continual, authentic assessment, conducted through a plethora of questions, tests knowledge and understanding. We also ask open-ended and "what if" questions. Performance assessment involves laboratory activities to actually characterize evidence and solve a crime, with the premise that all conclusions must be justified and defended, if necessary, as in a court of law.

The "crime scenes" we create are both logic- and laboratory-based and are used throughout the course to sharpen observation skills, deductive reasoning, and analytical thinking. The final exam, based on an elaborate crime scene, uses a resuscitation dummy (donated by a local fire department) as the deceased, liberally endowed with all sorts of clues that can be linked to various suspects. Once, a local television station even covered the finale.

Interspersed throughout the course are opportunities for further exploration. For instance, students have written imaginative, short (two- to three-page) mysteries like those in the short mystery series types of books. A government teacher can cover the aspects of law and constitutional rights or act as judge in mock trials. Ethical issues, such as those surrounding the use of DNA, can be discussed in a social science context.

Although our program has been successful, some teachers may have reservations about its practicality. Two major obstacles impede promulgation of a program such as ours. One problem may be a lack of confidence among teachers who are interested in forensic science but feel they do not have adequate backgrounds to tackle a whole course. These teachers should realize that teaching forensics is only a matter of applying fundamental scientific principles to a forensic science model. Also, no complete source of information exists that is aimed at a high school level, much less a hands-on, inquiry-based descriptive text or manual. However, information can be gleaned from resources such as local colleges and universities (criminal justice departments), various journal articles, college textbooks, local police departments, and forensic science websites. Thus, both obstacles are ameliorated, and we can give our students "the opportunity to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations and communicating scientific arguments" (National Research Council, 1996, 105). ✧

FIGURE 2.

Course syllabus.

First semester	Second semester
■ Introduction to the law	■ Mock trials
■ Evidence	■ Forensic anthropology
■ The crime scene	■ Serology research project
■ Fingerprints	■ Crime scene
■ Qualitative analysis	■ Document analysis
■ Hair analysis	■ DNA
■ Metal analysis	■ Firearms, toolmarks, and impressions
■ Research projects	■ Arson and explosives
■ Crime scene	■ Crime scene
■ Glass analysis	
■ Toxicology and poisons	
■ Fiber analysis	
■ Soil analysis	
■ Mock trials	

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REFERENCE

National Research Council. 1996. *National Science Education Standards*. Washington D.C.: National Academy Press.