5-E CLASSROOM STEM ACTIVITY:
RECONSTRUCTING EVENTS THROUGH PHYSICS

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If you're anything like me, your entire knowledge of forensics probably comes from what you've seen in movies and TV shows like CSI. Based on what happens in those shows, most of us know that forensics involves people using science to analyze fingerprints, DNA and other evidence to solve crimes or recreate events at the scenes of accidents.
CAUTION TAPE
Unsurprisingly, these shows oversimplify much of forensic science, amplify the drama and leave out some important details of what working in forensics is really like. While car chases and shootouts make for more interesting television, they don’t give an accurate representation of what really happens behind the caution tape.

By definition, forensic science is the application of science to criminal and civil laws. Forensic scientists collect, preserve and analyze scientific evidence during the course of an investigation. In truth, most jobs in forensics tend to be messy, fairly smelly, and rather unpleasant. But the people who choose this field take pride in their work and endure the difficult working conditions because they know that what they do is vital to the process of solving crimes.

There are many different careers available in the field of forensics. Crime scene investigator (CSI) is a real job title given to a police officer or civilian with scientific expertise. Crime scene investigators are responsible for securing a crime scene; taking detailed measurements and photographs; sketching and diagramming the scene; documenting, packaging and labeling evidence for transfer to the lab; attending and photographing autopsies; writing reports about evidence collection procedures and conclusions; and even testifying about their findings in court.

A forensic biologist is responsible for analyzing blood and other bodily fluids, hair and bones, and sometimes even things like insects and plant and animal remains to help identify victims and support criminal investigations. Once evidence is transferred to a lab, forensic biologists collect and analyze biological evidence found on things like clothing and other surfaces to determine the time and cause of death. While forensic biologists are responsible for examining all of the biological evidence from crime scenes, forensic chemists analyze all of the non-biological evidence. This means they are tasked with identifying unknown substances, along with analyzing drugs and other controlled substances taken from crime scenes and even people. They use very specialized and complex equipment to perform their duties. Both forensic biologists and chemists must carefully log everything they find and write reports that they may need to discuss in court.
High Five!
Forensic pathologists, or medical examiners, are typically the most highly trained members of forensic investigative teams. They examine bodies to determine the cause and manner (natural, accident, homicide, etc.) of death. To help them reach a conclusion, they examine evidence from the crime scene, go over witness statements, review the victim’s medical history, and perform an autopsy. They also review the findings of the other forensic scientists on the team to help them get a clearer picture of the events in question. Finally, they write a report on their findings and are typically called to testify about those findings in court.

To get a better understanding of the demands of being a forensic pathologist, I spoke to Dr. Cyril Wecht, who served as both the Allegheny County Coroner and Allegheny County Medical Examiner (Allegheny County is the county in Pennsylvania that includes the city of Pittsburgh) for many years, and has conducted over 14,000 autopsies. In addition to being a forensic pathologist, Dr. Wecht is also an attorney and medical-legal consultant. He is nationally known for his opinions on the JFK assassination, the death of Elvis Presley, the JonBenet Ramsey case, and the O.J. Simpson case among many others, along with the books he has published about these and other high-profile cases. He has also served as the president of the American Academy of Forensic Science and the American College of Legal Medicine.

“THE MOST REWARDING PART IS BEING INVOLVED IN A CASE AND MAKING A CONTRIBUTION THAT YOU FEEL LEADS TO JUSTICE.”

CYRIL WECHT
FORENSIC PATHOLOGIST
So how does someone become a forensic pathologist? “While I was in medical school, I thought about legal medicine and decided that I was going to go to law school when I finished medical school. I did that while I was doing my residency in pathology. I chose pathology because I came to learn that the medical specialty that is most frequently involved at the interface of law and medicine is forensic pathology,” explained Dr. Wecht.

Once he decided that he wanted to pursue this profession, Dr. Wecht cited some particular experiences that helped him along his path. “While I was in medical school thinking of law school and legal medicine, I got all kinds of opinions from people ranging from ‘You’ll be a fish out of water in both fields’ all the way to ‘You’ll make a million dollars immediately because you’ll be a doctor-lawyer.’ I finally got in touch with the most prominent medical-legal person in the country at the time, and went to the national conference in New York where he was giving the keynote address. He was gracious enough to sit down and talk with me for 15 to 20 minutes and I got a strong and valid understanding of what legal medicine was all about. I did the same thing with forensic pathology by talking with people involved in that field and realized that I was correct about forensic pathology being the area of medicine most frequently and relevantly involved in civil and criminal cases,” he said.

With his over 50 years in the forensics field to reflect upon, I asked Dr. Wecht about the most challenging part of his job, and the answer surprised me. I thought it would be the gruesome nature of the position or dealing with the families of victims. Instead, Dr. Wecht explained, “The most challenging part of the job is that, unlike many other fields of endeavor, you are going to be challenged. It is, by its very nature, a field in which people are challenging others. In legal medicine, civil and criminal cases involve attorneys and experts who present arguments and testimony. Often you’ll hear one side of the story and feel certain that’s how things happened, but then you hear the other side and suddenly you’re not so sure. In forensic science, contrary to what many people believe, there is only one absolute science in the field, and that is cellular DNA. Everything else is subject to challenge, including other types of DNA, fingerprints, footprints, and so on. You have to be prepared to do things correctly, objectively, and be prepared to be challenged.”

So what is the most rewarding part of being a forensic pathologist? “The most rewarding part is being involved in a case and making a contribution that you feel leads to justice,” he said. “But there are cases that have gone the other way where I did not feel that justice was served, which can be disappointing and stressful,” he added.

The forensics field is definitely not for the faint of heart or those with weak stomachs. But this growing field continues to draw scientific, analytical people who want to make a difference in the world - one case at a time.
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Here are some ideas for how high school teachers could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model.

Part 1: Engage

1. Have students read the article “Behind the Caution Tape - A Look at Forensics” in STEM Jobs magazine.

2. Discuss the types of evidence forensic scientists examine to reconstruct a crime or accident scene (blood/tissue/hair/DNA, footprints, fingerprints, ballistics, trajectories of projectiles, chemical residues, toxicology, etc.). Be sure to encourage students to take into consideration the fact that forensic scientists have to think about how forces act upon different objects to successfully recreate what happened during an incident. Ask students about the types of formulas and scientific principles that they may call upon (force = mass x acceleration, air resistance, inertia, effect of gravity, angle of trajectory, Newton’s Second Law, etc.).

3. Conclude the discussion by explaining to students that “Forensic scientists are only successful at their jobs when they are able to take the many pieces of evidence and information from a scene and put them together to paint a complete picture of what occurred. Their conclusions cannot just be based on intuition or guesswork - they must be based on scientific principles and facts that can be cited, explained, and shown in a court of law. There are two sides to every criminal or civil case, so their conclusions must also stand up to the facts and opinions presented by the attorneys from each side. In reality, forensic scientists are tasked with looking at clues in the present to determine - with certainty - what happened in the past.”

4. Show the brief video on misconceptions about falling objects that can be found at edu.STEMjobs.com/teacher-resources.

5. After watching the video, have students identify and define key terms such as weight, mass, acceleration, inertia, terminal velocity, drag, and gravity. This can be done informally via class discussion or more formally as entries in their science journals. Helpful definitions and formulas can be found at edu.STEMjobs.com/teacher-resources.

Part 2: Explore

1. Break the class into groups of 4 students. Tell students “Each group will be using their physics and math knowledge to solve a puzzle. Groups will then be presenting and defending their findings to the rest of the class.”

2. Present the following prompt: “Investigators found five objects at the base of the Empire State building: a bowling ball, a tennis ball, an inflated beach ball, a marble, and a cube-shaped empty cardboard box. They were able to measure and record the mass of each object, as shown in the table below. They consulted weather reports and found that there was no wind at the time of the incident. They found a slip of paper with the time it took each object to hit the ground written on it next to the objects, and that data is in the table below. They also know that the objects were released from the observation deck on the 102nd floor, based on witness statements. Witnesses disagree, however, about the manner and order in which the objects fell. That’s where you come in! Your group will use the information given to match each object to the most probable scenario.”
Part 3: Explain

Groups will present their findings to the remainder of the class. Presentations do not need to be overly polished, but should include the conclusions they made along with how they made them. They should discuss/show the formulas and logic used in a clear, concise way. Groups may have matched different objects to different scenarios, which is fine - as long as they can give scientific evidence to support their conclusions. Students may ask clarifying questions of each group after their presentation.

Students should reconvene with their groups to discuss how their findings differed from the other groups’ findings. Did any of the other groups’ conclusions and explanations make more sense than theirs? Do they want to change any of their conclusions based on the other presentations? Were there any factors that they failed to consider in their calculations? Were there things that their group thought of that other groups did not? What are their final conclusions after hearing the other presentations and feedback?

Part 4: Elaborate

Students should reconvene with their groups to discuss how their findings differed from the other groups’ findings. Did any of the other groups’ conclusions and explanations make more sense than theirs? Do they want to change any of their conclusions based on the other presentations? Were there any factors that they failed to consider in their calculations? Were there things that their group thought of that other groups did not? What are their final conclusions after hearing the other presentations and feedback?

Students should note major scientific takeaways in discussion or more formally in their science journals. Do objects of differing mass fall at the same speed when dropped from the same height? Why or why not?
Part 5: Evaluate

Students should create an entry in their science journals to answer the following prompt: Reflect upon the puzzle your group just solved. What do you think are some of the challenges faced by forensic scientists? How is it possible that the prosecution and defense in so many criminal cases have such different views of the same event based off of the same evidence?

Standards Addressed:

Next Generation Science Standards

HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Common Core State Standards - Math

CCSS.MATH.CONTENT.HSA.REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
CCSS.MATH.CONTENT.HSA.SSE.A.2 Use the structure of an expression to identify ways to rewrite it.
CCSS.MATH.CONTENT.HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law V = IR to highlight resistance R.

Cross-Curricular Connections

CCSS.ELA-Literacy.SL.9-10/11-12.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10/11-12 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.

Texas Essential Knowledge and Skills - Science

P.3.A in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student
P.4.B describe and analyze motion in one dimension using equations with the concepts of distance, displacement, speed, average velocity, instantaneous velocity, and acceleration
P.4.D calculate the effect of forces on objects, including the law of inertia, the relationship between force and acceleration, and the nature of force pairs between objects

Texas Essential Knowledge and Skills - Math

AI.1.A apply mathematics to problems arising in everyday life, society, and the workplace
AI.1.D communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate
AI.1.F analyze mathematical relationships to connect and communicate mathematical ideas
AI.1.G display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication
AI.12.E solve mathematic and scientific formulas, and other literal equations, for a specified variable