5-E CLASSROOM STEM ACTIVITY:
RECONSTRUCTING EVENTS THROUGH PHYSICS

Ellen Egley
Education Content Manager, STEM Jobs
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.

“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.”

DR. CYRIL WECHT
FORENSIC PATHOLOGIST
DEGREES: MEDICAL DEGREE FROM THE UNIVERSITY OF PITTSBURGH.
LAW DEGREE FROM THE UNIVERSITY OF MARYLAND
YEARS IN THE INDUSTRY: 50+
STEM TYPE: INVESTIGATOR

PHOTO © CYRILWECHT.COM
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
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— 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.
**5-E CLASSROOM STEM ACTIVITY: RECONSTRUCTING EVENTS THROUGH PHYSICS**

Here are some ideas for how middle 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 with students some of the things that forensic scientists investigate (crimes, industrial accidents, fires, car accidents, etc.). Explain that in order to recreate events that led to things like car accidents, forensic scientists must have a deep understanding of how forces interact and act on objects.
3. Show students the video on Newton’s Laws of Motion that can be found at [edu.STEMjobs.com/teacher-resources](http://edu.STEMjobs.com/teacher-resources).
4. Discuss with students when they’ve experienced these laws in their own lives. Examples of inertia could include riding a roller coaster, the feeling when the driver of a car slams on the brakes, etc. Examples of the second law could include larger machines (like barges or semi-trucks) needing larger engines to move them, or students needing to pedal harder to get their bikes up a steep hill to combat the force of gravity acting on their mass.

**Part 2: Explore**

Break students into groups of 4-5. Each group will need a toy car (best results if all toy cars have a similar mass), stack of textbooks, clay or Play-Doh, ruler, empty tissue box, and ramp (a board or stiff piece of cardboard will work well).

1. Groups will place one end of the ramp on the stack of books and the other on a tabletop or floor. A heavy book will be placed a short distance from the bottom of the ramp (use a lighter book if the cars are very small). Groups will create a figure from the clay to go on the car so that the effects of inertia can be seen more easily.
2. Tell students that they will be comparing the effects of two different collisions. In the first, a toy car will collide with a heavy object, like a book. In the second, the toy car will collide with a lighter object, like a tissue box. Prior to starting the activity, discuss some of the following issues and record your answers in the scientific method handout.
   a. Discuss what scientific question the experiment is trying to answer.
   b. Have students think about their own experiences and observations regarding moving objects colliding with other objects. Make sure they consider questions such as “When riding a bike, are you more likely to get hurt when you hit a heavy object, like a curb/wall/tree, or a lighter object, like a rock/branch/shrub?”
   c. Have the class work in small groups to develop hypotheses about the toy car collisions based on those observations, and enter their hypotheses on the scientific method handout.
3. Have groups conduct the first version of the experiment with the book at the bottom of the ramp. Remind them to think about how far the car, figure, and book traveled after the collision. Results can be recorded on the scientific method handout as they conduct multiple trials.
4. Tell them that they are going to repeat the experiment, but this time there will be an empty tissue box at the bottom of the ramp instead of a book. How will this change the results? Why? Complete new hypotheses on the handout and then conduct multiple trials of the second experiment.
Part 3: Explain

Create a table (on the board, chart paper, etc.) and have each group record their findings from both experiments (see sample below). They should average the results from their trials for each version. Have students share each group’s findings with the class and formulate some conclusions. Consider questions such as: What patterns do they see in the data? Are the results consistent enough to form a conclusion? Is more research needed to definitively confirm or disprove their hypotheses? What conclusion(s) can they make based on the data collected? Does the data prove or disprove their hypotheses? Have students record their conclusions on the scientific method handout.

Sample Table

<table>
<thead>
<tr>
<th>Group</th>
<th>Distance Car Travels After the Crash</th>
<th>Distance Figure Travels After the Crash</th>
<th>Distance Obstacle Moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue Box</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Part 4: Elaborate

1. **Background Information:** One of the things that makes the scientific method so valuable is that it helps scientists control the variables – the elements of the experiment that can be modified - that can affect the outcome of the experiment. It is important that only one variable be changed at a time so that there is a clear, direct link between that variable and the outcome.

2. **With the Class:** Have students discuss which variable changed during their experiments and how it affected the outcome. Then lead a class discussion about what would have happened if they had changed the height of the ramp or the size of the car between the book and tissue box collisions. Would they still be able to make data-supported conclusions about the effect of the obstacle’s mass on the severity of the crash?

3. Students will now conduct the experiment again. This time, however, the mass of the obstacle will stay the same (groups can pick either the book or the tissue box) and the height of the ramp will change. Have groups use the scientific method again to form hypotheses about what will happen when the height of the ramp changes. Ensure that the height of each group’s ramp changes enough between trials to significantly impact the speed of the car.

Part 5: Evaluate

Have students answer the following questions in their science journals:

1. Which parts of the experiment demonstrated Newton’s First Law of Motion? Second? Third?

2. How could forensic investigators use their understanding of forces acting on objects to reconstruct events such as a car accident to determine what occurred?

3. You conducted a controlled experiment where the variables were known. What challenges would investigators face in the real world, and what variables would they have to consider when investigating an accident?
Standards Addressed:

Next Generation Science Standards
MS-PS2-1. Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.

Common Core State Standards - Math
CCSS.MATH.CONTENT.6.SP.B.5.B Summarize numerical data sets in relation to their context, such as by:
B. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
CCSS.MATH.CONTENT.6.SP.B.5.C Summarize numerical data sets in relation to their context, such as by:
C. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

Cross-Curricular Connections
CCSS.ELA-Literacy.SL.7/8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7/8 topics, texts, and issues, building on others’ ideas and expressing their own clearly.

Texas Essential Knowledge and Skills - Science
6.2.B design and implement experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology
6.2.E analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends
7.2.B design and implement experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology
7.2.E analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends
8.2.B design and implement comparative and experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology
8.2.E analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends
8.6.C investigate and describe applications of Newton’s law of inertia, law of force and acceleration, and law of action-reaction such as in vehicle restraints, sports activities, amusement park rides, Earth’s tectonic activities, and rocket launches

Texas Essential Knowledge and Skills - Mathematics
6.12.C summarize numeric data with numerical summaries, including the mean and median (measures of center) and the range and interquartile range (IQR) (measures of spread), and use these summaries to describe the center, spread, and shape of the data distribution
<table>
<thead>
<tr>
<th><strong>THE SCIENTIFIC METHOD</strong></th>
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<tbody>
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<td><strong>NAME:</strong></td>
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<th><strong>Scientific Problem or Question</strong></th>
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<th><strong>Observations from Real Life</strong></th>
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<th><strong>Hypothesis (Educated Guess)</strong></th>
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