NAME: ______________________________________

DATE: ______________________________________

Evidence Record

Height (cm)	Diameter of Drop 1 (mm)	Diameter of Drop 2 (mm)	Diameter of Drop 3 (mm)	Average Diameter of Drops (mm)	Shape and General Observations of Blood Splatters
10					
20					
30					
40					
50					
60					
80					
100					
120					
140					
160					
180					
200					
Crime Scene					

r^2 value for linear fit (rounded to four decimal places): _____________

r^2 value for natural logarithm fit:_______________

r^2 value for quadratic fit:________________

r^2 value for power curve fit:_______________

type of curve that gives best fit to data:________________________

equation for best fit: **Y**=____________________

calculated height of spatters from crime scene: **X**= __________________

Case Analysis

1. Which type of curve gave the best fit to your data?
2. Did the shape of the blood spatters change as the height increased? Explain.
3. Which of the suspects could have created the blood spatters at the crime scene? Explain.
4. How accurate do you think your height estimate is? What factors can contribute to inaccuracy in your estimate? How can you reduce the errors from these factors?
5. Forensic scientists often do tests to determine the relationship between height and spatter diameter for the different cases they are involved in. What factors can cause the relationship between height and spatter diameter to differ from crime scene to crime scene?

Case File 10
Dropped at the Scene: Blood spatter analysis

Teacher Notes

Teaching time: two class periods

This lab introduces students to the science behind blood spatter analysis. It also provides a clear demonstration of the relationship between r^2 values and the goodness of fit of various curves.

Tips

- If students are having difficulty grasping the relationship between r^2 and goodness of fit, you can have them graph the various types of curves, along with their data, to show that some curves follow the data well while others don't. Simply press GRAPH after computing each type of curve to see the data with the curve superimposed. Press TRACE and then use the arrow keys to move between the different curves and the data.
- Case File 1, Tracks of a Killer, follows similar procedures. Refer students to screen shots in that activity if they are having trouble.

Lab Preparation

- Synthetic blood can be purchased from scientific supply houses, or you can use milk or Pepto-Bismol™ with a little red food coloring.
- Before class, you will need to create the crime scene evidence by dropping 3 drops of simulated blood from a known height between 10 and 200 cm. Use the "blood" and dropper type that your students will use. Select the height so that one or more of the suspects are implicated (depending on how clear-cut you want your students' results to be). Keep in mind that someone who is 5 ft tall could not create a blood drop that falls from 6 ft if the drop were produced by a nosebleed, but someone who is 6 ft tall *could* produce a drop from 5 ft if he or she bent over after being hit. The spatters you create should be given to the students as part of the evidence.
- This activity is best done in groups of at least two so that the students are able to measure heights and create spatters at the same time.
- Using dropper bottles instead of pipettes may be less messy.
- You may want to let spatters dry before measuring.

Resources

http://www.bloodspatter.com/BPATutorial.htm
Blood Stain Pattern Analysis Tutorial includes examples of origin determination and impact velocity calculation.

http://www.benecke.com/bloodspatteraafs2005.html
The short, scholarly article at this site discusses the effects of surface structure and drop height on blood spatter patterns.

Modifications

- For less-advanced students, eliminate steps 6–8 and stick with a linear fit (or choose another single curve that seems to fit your particular situation better).
- If time is short, collect fewer data on known-height blood drops.

- For more-advanced students, create crime scene evidence by dropping blood from a height outside the range of the heights the students will measure. In this case, it will be necessary for the students to use the equation for the best fit curve to calculate the approximate height of the crime scene drops. You may also allow the students to try other types of curves, such as exponential or logistic.
- If extra time is available, have students perform the experiment on different types of surfaces (e.g., carpet, cardboard, towels, wood, tile) to determine how the relationship between height and spatter size can change from one surface to another. Alternatively, give each group a different surface to experiment with and then compare the results.
- As an extension activity to introduce more mathematics, have the students determine a relationship between angle of impact and the shape of the resulting spatter. The resources given above contain additional information on how to do it.

Sample Data (using Pepto-Bismol)

Height (cm)	Diameter of Drop 1 (mm)	Diameter of Drop 2 (mm)	Diameter of Drop 3 (mm)	Average Diameter of Drops (mm)	Shape and General Observations of Blood Splatters
10	7	7	7	7	
20	10	10	12	10.7	
30	10	13	12	11.7	
40	14	12	13	13	
50	12	13	13	12.7	
60	14	14	14	14	
80	15	16	15	15.3	
100	17	17	17	17	
120	18	18	18	18	
140	18	18	18	18	
160	18	18	18	18	
180	20	20	20	20	
200	20	20	20	20	
Crime Scene	11	12	11	11.3	

r^2 value for linear fit (rounded to four decimal places): 0.8909

r^2 value for natural logarithm fit: 0.978

r^2 value for quadratic fit: 0.9582

r^2 value for power curve fit: 0.9679

type of curve that gives best fit to data: natural logarithm

equation for best fit: **Y**= $^{-}2.77 + 4.23 \ln X$

calculated height of spatters from crime scene: **X**= 27.4 cm

(equation for linear fit: **$Y1 = .058X + 9.7$**)

(equation for quadratic fit: **$Y3 = -3.22E^{-}4X^2+0.124X+7.57$**)

(equation for power curve fit: **$Y4 = 3.75X^{0.123}$**)

Case Analysis Answers

1. Which type of curve gave the best fit to your data?
   Answers may vary. In this case, the natural logarithm gave the best fit to the data. However, the relationship between height and diameter can vary, depending on the nature of the surface and the "blood" used.
2. Did the shape of the blood spatters change as the height increased? Explain.
   Answers may vary. Drops that fall greater distances may have more ragged edges because they are moving more quickly when they hit. Drops that fall farther may also form secondary drops as liquid bounces off the paper.
3. Which of the suspects could have created the blood spatters at the crime scene? Explain.
   In this case, any of the three suspects could have produced the spatters because the approximate height is only about 30 cm. Students should indicate the understanding that blood drops of a certain height can be produced by someone **taller** ***than that height but are not likely to be produced by someone*** **shorter** ***than that height.***
4. How accurate do you think your height estimate is? What factors can contribute to inaccuracy in your estimate? How can you reduce the errors from these factors?
   Answers may vary. Inaccuracies in drop height estimates can arise from a variety of sources, including inaccurate or imprecise measurement of test drops and heights, relatively poor fit of the bestfit curve, too few data points collected, and differences between the experimental and actual conditions (e.g., surfaces, air temperature and humidity, wind conditions).
5. Forensic scientists often do tests to determine the relationship between height and spatter diameter for the different cases they are involved in. What factors can cause the relationship between height and spatter diameter to differ from crime scene to crime scene?
   Factors that can influence the shape and/or size of a blood splatter include the following: consistency of the blood (although it is generally stable, it can change within a certain range); speed at which the drops are traveling; angle at which the drops hit the surface; type of surface the drops are hitting; amount of time between when the spatters were made and when they were measured; and environmental conditions at the scene (e.g., temperature, wind, humidity).