Case File 10

Dropped at the Scene: Blood spatter analysis

Analyze blood spatter evidence and help identify Jessica Barnes' killer.

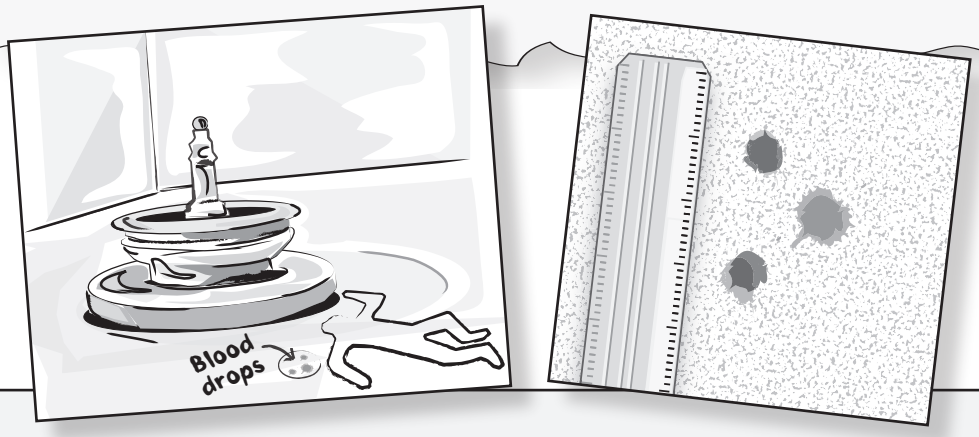
Re: Police Detective Status: Barnes Murder

Museum curator Jessica Barnes was found dead on 10/05/05, the day before the grand opening of the world famous traveling exhibit Shadows of Egypt. Her body was found at the base of the large marble fountain in the center of the museum lobby.

It was clear that the victim was strangled. A few drops of blood were found on the tile floor, but blood tests show that the blood is not the victim's. Investigators have found traces of the same blood on the knuckles of the victim's hand. Investigators are suggesting that she fought her attacker, giving him or her a bloody nose or lip, and that the blood dripped onto the floor as the attacker fled the scene.

The small volume of blood suggests that the wound was minor and, thus, would have nearly healed by the time the suspects were apprehended. Indeed, none of the prime suspects showed evidence of a facial injury of any kind.

We may be able to narrow down the height of the killer from the blood spatter evidence. (We need this to order blood tests.)



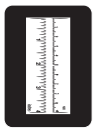
Barnes Murder
Suspect List
Three other museum employees were working after hours the night Ms. Barnes was killed:
Abraham Stein, photo archivist: 6'2"/ brown eyes/ brown hair
- knew Barnes was trying to cut funding for his vintage photo department
Ellie Walsh, museum curator: 5'3"/ green eyes/ brown hair
- was a candidate for the head curator position six months ago, along with Barnes—Barnes given position
Keith Hartman, administrative assistant: 5'8"/ blue eyes/ bleached blond hair
- was recently fired by Barnes and finishing his remaining two weeks in the position

Forensics Objective

- determine the height of a source of blood spatters or drops

Science and Mathematics Objectives

- graph data to find quantitative relationships
- create a standard reference curve for comparison with unknown data



Materials (for each group)

- TI-83/TI-84 Plus™ Family
- newspaper
- 13 pieces of white paper
- disposable pipettes or droppers
- simulated blood
- calipers, or compass and metric ruler
- meterstick

Procedure

Part I: Collecting the Data

1. Create blood spatters from known heights and compare them with unknown samples.
   a) Spread newspaper on the ground. Place a piece of white paper on the newspaper.
   b) Fill a pipette with simulated blood. Drop a single drop onto the white paper from a height of 10 cm.
   c) Measure the diameter of the spatter in millimeters, using calipers or a compass. (Note: If the spatter has a ragged edge, measure *only* the diameter of the main blood drop; do *not* include any ragged edges in your measurement.) Record the diameter in the Evidence Record, along with any observations you can make about the shape of the spatter.
   d) Repeat steps 1b and 1c twice more, moving the pipette to slightly different locations but maintaining a height of 10 cm.
   e) Calculate the average diameter of the spatter that fell from 10 cm, and record it in the Evidence Record.
   f) Replace the white paper with a clean sheet. Repeat steps 1b–1e from a height of 20 cm.
   g) Repeat step 1f for each remaining height in the Evidence Record.
   h) Now measure the diameter of each spatter in the crime scene evidence, calculate the average diameter of the crime scene spatters, and enter the data into the Evidence Record.

2. Enter the height and diameter data into lists in your calculator.
   a) Press STAT ENTER to enter the data list editor.

If there are old data in any of the lists, clear them by using the arrow keys to select the list heading (L1, L2, etc.) and then pressing CLEAR ENTER.

   b) In list L1, enter the heights that the drops fell.
   c) Enter the average diameter of the spatters in list L2. (Do *not* enter the data from the crime scene into the lists.)

Part II: Analyzing the Data

3. Start your analysis by graphing the drop height versus the average spatter diameter.
   a) Press 2nd Y= to enter the Stat Plot menu.

Make sure all the other graphs are turned off before you plot your data. To turn off all other plots, select option **4: PlotsOff** before proceeding with step 3b.

b) Choose **Plot1** by pressing ENTER. On the resulting screen, turn on the plot by using the arrow keys and pressing ENTER when **On** is highlighted.
c) Choose a dot (scatter) graph, the first of the pictured graphs, by using the arrow keys and pressing ENTER when the first pictured graph is highlighted.
d) Plot the heights of the drops on the *x*-axis by selecting L1 (press 2nd 1) for the **Xlist**. Plot the diameters of the splatters on the *y*-axis by selecting L2 (press 2nd 2) for the **Ylist**. Press ENTER.
e) To set the scaling values for the graph window, press ZOOM. Select option **9: Zoom Stat** to have the calculator automatically set the window scaling to fit your data.
f) Examine the graph of your data points. Do they seem to fall along a straight line or a curve?

4. In order to figure out what kind of relationship there is between height and blood spatter diameter, you will now test several different types of curves to see which gives the best fit to your data. To determine which type of curve fits the data best, you will need to compare the r^2 values for the different fits. An r^2 value near 1 means that a curve fits the data very well. To have the calculator find r^2 values for the different curves, turn on its Diagnostic function.
   a) Press 2nd 0 to enter the calculator's function catalog.
   b) Use the arrow keys to scroll down until **DiagnosticOn** is highlighted. Press ENTER to select **DiagnosticOn**, and then press ENTER again to execute the function. **Done** will appear on your Home screen if you have done this correctly.

5. The first curve you will attempt to fit to your data will be a linear curve (a straight line). Perform a linear regression on the data to determine an equation that will allow you to predict the height a blood drop fell from if you know the size of the spatter it left behind.
   a) Press STAT ▶ to select the **CALC** menu.
   b) Select option **4: LinReg(ax+b)**, and the LinReg program should appear on your Home screen.
   c) To tell the calculator to calculate an equation relating the data in list L1 to the data in list L2, press 2nd 1 , 2nd 2 ,.
   d) Tell the calculator to store the data in variable Y1 by pressing VARS ▶ ENTER ENTER.
   e) Press ENTER to execute the linear regression. A table will print out on your screen; it will give the equation describing your data, the coefficients for the equation, and the r^2 value.
   f) Record the equation and the r^2 value to four decimal places in the Evidence Record.

6. Next, try to fit a natural logarithm curve to the data. Repeat step 5 with these modifications:
   a) In step 5b, select option **9: LnReg**.
   b) In step 5d, tell the calculator to store the equation in variable Y2 by pressing VARS ▶ ENTER, scrolling down to **Y2**, and pressing ENTER.

7. Try to fit a quadratic curve to the data. Repeat step 5 with the following modifications:
   a) In step 5b, select option **5: QuadReg**.
   b) In step 5d, tell the calculator to store the equation in variable Y3.

8. Try to fit a power curve to the data. Repeat step 5 with the following modifications:
   a) In step 5b, select option **A: PwrReg**.
   b) In step 5d, tell the calculator to store the equation in variable Y4.

9. Next, determine which type of curve best fits your data.
   a) Examine the r^2 values of the four different curves recorded in your Evidence Record. The curve with the r^2 value closest to 1 best fits your data.
   b) Press Y= to see the list of variables. Determine which equation best fits your data. Use the arrow keys and CLEAR to delete the equations for the other types of curves.
   c) Record the equation of the best fit curve in the Evidence Record.

d) To see a graph of your data with the best fitting curve, press GRAPH.

10. Estimate the height from which the blood at the crime scene fell by comparing it to your known data.
    a) To trace the graph, press TRACE and then ▲ to move from the individual data points to the graph. When the line is selected, the equation of the line will be shown at the top of the screen.
    b) Use the arrow keys to trace the line until the value of the **Y =** at the bottom of the screen is as close as possible to the average diameter of the blood spatters from the crime scene.
    c) Record the **X =** number from the bottom of the screen. This is the estimated height, in centimeters, from which the blood at the crime scene fell.