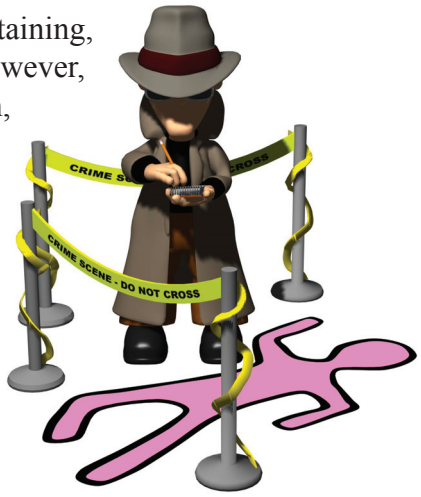
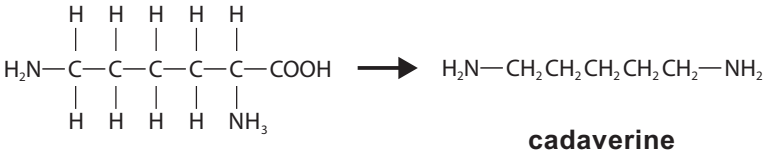
ACTIVITY 14

Time of Death: When Did It Happen?

Physical observation methods such as body temperature, post-mortem staining, and rigor-mortis are used to gain a rough estimate of time of death.[1] However, these indicators are not very accurate in their estimation of time of death, and can sometimes be contradictory. What is needed is a technique that can more precisely measure the elapsed time since death. Some recent developments include analyzing the serum concentration of Na^+ and lysine in the body.[1,2]





lysine → **cadaverine (1,5-pentanediamine)**

After death, serum sodium ion and lysine concentrations decrease. The amount of Na^+ decreases because the person no longer consumes sodium-containing substances and the kidneys are no longer functioning. Lysine is decarboxylated to form cadaverine and CO_2.[2] It is the production of cadaverine, along with other compounds, that causes decaying bodies to have such a foul odor. In this activity you will compare the time of death determinations for a homicide victim, Mr. Pink, using both the Na^+ and lysine methods.

Prerequisite Knowledge

Before beginning this activity, you should be able to

- Graph concentrations of reactants and products of reactions as function of time
- Use graphs to determine if a reaction exhibits zero, first, or second order kinetics
- Determine the rate constant for a reaction from kinetic data, including appropriate units
- Write the rate law for a reaction based on experimental data
- Select and use the appropriate integrated rate equation

Applying Your New Skills

After completing this activity, you should be able to

- Predict concentrations of Na^+ and lysine at any time after death occurs
- Predict concentrations of compounds of interest versus time from kinetic data in a variety of applications

Contributed by Brett Simpson and Austin Hitt, Coastal Carolina University
Revised by Cheryl Coolidge, Colby-Sawyer College, and Darlene Slusher and John Goodwin, Coastal Carolina University

The Problem

Early Thursday morning, Mr. Pink was found dead at the side of a deserted stretch of country road. Medical Examiner Quincy picked up the body and brought it back to the morgue. He concluded that the cause of death was a gun shot wound to the chest. However, he is unsure *when* the murder took place. Quincy turns the case over to his assistant...you! Your job is to determine the time of death.

Because he may be asked to testify in court, Quincy requires that you use two different methods to corroborate the time of death and that your analysis be as accurate as possible with each method. He provides you with standard calibration data relating the sodium ion and lysine concentrations to the time elapsed since death occurred (Tables 1 and 2). As instructed by Quincy, you measure Mr. Pink's serum sodium ion and lysine levels at 6:00 a.m. and obtain the following results: the Na^+ ion concentration in Mr. Pink's blood serum is 125.4 mM (mmol/L) and the amount of free lysine found in the body is 0.027 mM.

Table 1 Sodium Ion Calibration

Sodium ion concentrations following death. This reaction is zero order. Plot the data to obtain the rate constant for this reaction.

Time (hours)	$[Na^+]$, (mM)
5.16	128.06
9.95	125.95
15.44	124.07
21.51	120.88
26.73	118.92
33.87	115.88
39.09	114.02
45.06	111.89
52.91	109.25

Table 2 Lysine Calibration

Lysine and cadaverine concentrations following death. Plot the data in different ways to determine the order of the this reaction and to obtain the rate constant for the reaction.

Time (hours)	[Lysine] (mM)	[Cadaverine] (mM)
0	0.100	0.000
3	0.0750	0.025
6	0.0550	0.045
9	0.0400	0.060
12	0.0300	0.070
15	0.0200	0.080
18	0.0150	0.085
21	0.0090	0.091
24	0.0080	0.092
27	0.0060	0.094
30	0.0050	0.095

Solve the Problem and Document Your Solution

Name: _____

Other Team Members: _____

Date: _____ Activity Title: _____

Level of Help used to solve this problem by the team: ***none*** ❒ ***Au*** ❒ ***Ag*** ❒ ***Cu*** ❒

Work with your team to solve the problem. Your instructor can provide three levels of help called gold, silver, and copper. *Au Help* presents a strategy that resembles the way experts think when they solve problems. The use of this strategy is illustrated and prompted to different degrees in *Ag Help* and *Cu Help*. As the semester progresses, you should move through these stages of *Help* to grow your problem solving skills. Your instructor will tell you what you need to do to document your solution. One method would be to provide the information requested in *Au Help*.

Does Your Answer Make Sense?

1. Do your two results agree with each other well enough to pin a suspect down at a particular time?

2. Is there anything about the quality of the data that would lead you to trust one method over the other? If so, explain. If not, how would you decide the time of death to report in a way that you could best defend it, if you were called to testify in court?

Building Your Problem-Solving Skills

You will be able to complete the *Got It!* section, which comes next, more efficiently, and you will do better on exams if you take a few minutes now to improve your problem-solving skills. Communicating the steps in your problem solution to others and thinking back on the problem that you just completed will help you to improve.

1. Share your team's problem solution with your class as called upon by the instructor.
2. Identify the most important thing you learned about problem solving today that will help you solve new problems.

3. Consider whether you could solve this problem using a more efficient procedure so you can answer a similar exam question more quickly. If you find one, describe this more efficient procedure.

4. Identify whether there are any issues or assumptions contained in the problem and its solution that would limit using the same procedure for other problems.

5. Identify features of this problem and its solution that could apply to other problems.

Got it!

1. Suppose that you did not find Mr. Pink until 22.0 hours after his death. Based on integrated rate equations, what would you expect his Na^+ level to be? His lysine level?

2. Before you stock a backyard pond with trout, you have the water analyzed to check for contamination. You find that the pond contains a chemical that is toxic. You call the local Department of Fish and Game and they inform you that adding certain bacteria to your pond will decompose this chemical and make it nontoxic. They tell you the amount of bacteria to add and that the rate constant for the decomposition then will be 0.41 $month^{-1}$, but they fail to tell you whether the decomposition is zero, first, or second order. If the concentration of this chemical in your pond is 1.34 M, and trout can survive at a concentration of 0.20 M, how long will it be until you can stock your pond?

References

[1]Singh, D. et al. Linearization of the relationship between serum sodium, potassium concentration, their ratio and time since death in Chandigarh zone of north-west India. *Forensic Science International* **2002,** *130*, 1-7.

[2]Haglund, W.D., Sorg, M.H., Eds. *Forensic Taphonomy: The Postmortem Fate of Human Remains* [Online]; CRC Press LLC: Boca Raton, FL, 1997; p. 100.