

The Mystery of the Seven Deaths

Cellular Respiration Case Study

Part I – The Symptoms

Imagine that you work as a medical examiner in New Brunswick. In this role, you investigate suspicious deaths and provide toxicology services for the province. Unfortunately, it's been a busy week. In the past five days, seven people have died, all with similar symptoms. It is your job to examine the data and determine the cause of death for these victims.

The first was a 12-year-old girl. Her parents said that she was awake in the middle of the night complaining of a stuffy nose and sore throat. They gave her an extra strength Tylenol and sent her back to bed. At 7am the next morning, the parents discovered that the girl had collapsed on the bathroom floor. An ambulance rushed the girl to a nearby hospital, where she was pronounced dead.

That same day, paramedics found the second victim unconscious on his kitchen floor after what they thought was an apparent heart attack. Sadly, the victim's brother and fiancée also collapsed later that night while the family gathered to mourn his passing. Both had taken Tylenol to help them cope with their loss shortly before collapsing; neither survived.

In the next four days, three other similar deaths were reported, all in the same neighborhood and all with similar symptoms.

Are these seven deaths related? What is causing these people to die? It is your job to answer these questions before more deaths are reported.

Symptoms exhibited by most patients:

- Dizziness
- Confusion
- Headache
- Shortness of breath/rapid breathing
- Vomiting

Most deaths were very rapid, occurring within a few hours of symptoms.

1. [SP 3] a) Identify the similarities or connections between the seven individuals.
b) Pose some questions you would want to ask the families to establish connections between the seven individuals.
2. [SP 6] State whether you believe the seven deaths connected. Justify your response.

Part II – Autopsy Report

- Immediate cause of death was hypoxia.
 - Tissue sections from heart, lung, kidney, and liver all show massive cell death.
 - Staining with specific dyes showed major mitochondrial damage within the affected tissues.
 - Oxygen levels in the patients' blood were approximately 110 mm Hg (normal range is 75 – 100 mm Hg).
3. [SP 1] a) Recalling your knowledge of the function of organelles, describe the function of the cells that was interrupted in these patients.
b) Provide reasoning whether this loss of function could lead to the death of these individuals.
4. [SP 1] Given the data in the autopsy, describe the conclusions that seemed inconsistent with the immediate cause of death.

Part III – Subcellular Metabolite Analysis

Detailed analysis of the damaged cells showed that ATP levels in the mitochondria were very low. Levels of pyruvate and acetyl coenzyme A (CoA) were normal. You begin to suspect a malfunction of a specific cellular metabolic pathway and so you request a more detailed analysis of the sub-cellular components of the affected cells from the autopsy. The levels of key metabolites are reported below:

Metabolite	Patient Level	Normal Level
Glucose	99 μM	100 μM
Pyruvate	27 μM	25 μM
NAD ⁺	10 μM	75 μM
NADH	400 μM	50 μM

5. [SP 1] For each metabolite listed in the table, describe its role in cellular respiration.
6. [SP 4] Describe any abnormalities in the levels of these metabolites in the victims.
7. [SP 3] Based on these abnormalities, propose a hypothesis about which pathway may be affected and a cause of death. Give the reasoning for your hypothesis.

Part IV – Role of Cyanide

You are now convinced that you know the cause of death for these victims and quickly report it back to the police as this is a very dangerous situation. After realizing that the electron transport chain was no longer functioning, you started to suspect poisoning and ran a blood test for various poisons that you knew affected the electron transport chain. The test of all seven patients came back positive for cyanide. Cyanide irreversibly binds to cytochrome c oxidase of the electron transport chain and prevents the transfer of electrons to oxygen, the final electron acceptor.

8. [SP 6] Explain the effect cyanide would have on the electron transport chain and the production of ATP.
9. [SP 1, SP 6] Given what you now know about the action of cyanide on cellular respiration, explain why the patients died of lack of oxygen while their blood oxygen levels were normal.
10. [SP 6] Predict whether artificial respiration or oxygenation would have saved these people. Justify your prediction.
11. [SP 3] Looking back at the information you have about the people before they got sick, propose a possible source of the cyanide poisoning. Describe the response public health officials and police should have to these events.