The Effects of Natural and Synthesized Pollutants on the Rate of Cellular Respiration over an Abbreviated Period of Time

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Abstract

Pollution is a dangerous harm to the environment in which we live, which permeates how we survive and our daily life. This study examines the effects of pollution on cellular respiration in a small living organism, yeast, and shows that even in the presence of a carbohydrate, yeast’s production of carbon dioxide, and therefore its rate of cellular respiration, is dramatically lowered and at times appears to be halted entirely by pollution. This kind of disruption of cellular respiration in the environment on a massive scale could have a large impact on our way of life and survival.

*Keywords*: cellular respiration, pollution, carbon dioxide

Introduction

The purpose of this study is to evaluate the effects of pollutants on cellular respiration of small particles (in this experiment, yeast), in order to broaden the ability to see the long term effects of a lower rate of cellular respiration in the environment. Increase of contamination in the environment can have a direct effect on human respiration (Fortoul et al., 2011), damaging our ability to live healthy and survive on Earth. Additionally, this kind of permeating air pollution can lead to long-term plant impairment (Zeiger, 2006). Unnatural influence over the rate of cellular respiration could have unforeseen consequences. For example, cellular respiration has been directly linked to the pH levels in lake water, where a lower rate of cellular respiration results in a more basic pH value (Dropp et al., n.d.). The product of this could be an altered habitat with an entirely different sets of species.

The results of this experiment have a predicted twofold outcome. It is hypothesized that the first half of this experiment will show that yeast and water produces more carbon dioxide, and therefore undergoes a higher rate of cellular respiration, in the presence of a carbohydrate (sugar). In the second half of this experiment, by testing the yeast, water, and sugar mixture with a number of natural and synthesized pollutants it is hypothesized that yeast, water, and a carbohydrate will have a lower rate of cellular respiration and therefore produce less carbon dioxide in the presence of pollution, demonstrating the hazardous and potentially damaging effects of pollution on cellular respiration in the environment.

Methods

The experiment was completed in line with Dr. Kim Largen’s *Environmental Science Lab Manual and Notebook Volume 1: The Science* (2012, p. 113, 114). Two fifteen milliliter culture tubes, two four dram shell vials, and two twenty-five milliliter beakers were each labelled on of:

*#1-Y+W*

*#2-Y+S+W*

Where Y stood for yeast, W stood for water, and S stood for sugar. Then, one and twenty-five hundredths of dry active yeast were measured into both beakers. Additionally, to the second beaker (labelled #2-Y+S+W) one and twenty-five hundredths of sugar was added and thoroughly mixed with the yeast currently present. Measured with a granulated cylinder, thirteen milliliters of warm tap water was thoroughly mixed with the contents of both beakers. The temperature of the water was warm enough to activate the living yeast particles without being hot enough to kill them. At this point the contents of the first beaker were poured into the first culture tube (both labelled #1-Y+W), and the first vial was placed into the culture tube. Using an index finger to support the culture tube, the tube and vial were quickly inverted while held together, so that the culture tube was now sitting, upside-down, in the vial. This caused the air space to flow to the top (which was the bottom of the inverted culture tube), allowing the researcher to easily track carbon dioxide (CO2) accumulation. Once placed, the vial and culture tube were not touched again during the observing period.

The observing period began immediately by recording the initial gas volume in the culture tube, in milliliters, as the value when the time was equal to zero. The process of adding a vial, inverting the vial and tube, and recording the initial gas volume was then repeated with the second beaker, vial, and tube. After the beginning of the observing period for each vial and tube set, the gas volume in milliliters was recorded every minute for ten minutes, with the gas level read between the liquid and the bubbles produced.

In another beaker, one and twenty-five hundredths dry active yeast were thoroughly mixed with equal parts sugar. Afterwards ten milliliters of warm (as last time, warm but not hot) water was added to the beaker and mixed well. Each group then added one of the following natural or synthesized pollutants to their mixture: isopropyl alcohol, vinegar, salt solution (ten percent salt), baking soda solution (five percent baking soda), bleach solution (one percent bleach), soap solution (ten percent soap). The polluted solution was then treated as the two past solutions were (poured into a culture tube, topped with a vial, and inverted). The data for each pollutant was collected in the same manner as the previous solutions, for ten minutes. For each of the polluted solutions, the total volume of carbon dioxide produced (volume at ten minutes minus the volume at zero minutes) and the rate of cellular respiration (total volume of carbon dioxide divided by the total number of minutes) were calculated and recorded.

Results

Figure 1. Recorded gas volume with and without sugar, the acting carbohydrate

Figure 2. Recorded gas volume when one of the simulated pollutants are present

Figure 3. Calculated cellular respiration rate and volume of carbon dioxide produced

The first test resulted in carbon dioxide being produced with the contents yeast, sugar, and water but nothing produced with the contents yeast and water. See Figure 1 for a dynamic representation of the carbon dioxide accumulation over the given period of time. Results pertaining to the second test show that three of the polluted mixtures did not yield any carbon dioxide at all (isopropyl alcohol, vinegar, and the baking soda solution) in the allotted time given. The other mixtures produced carbon dioxide after the five-minute mark or, in the case of the salt solution, in a short burst within the first minute before levelling out. Figure 2 shows the differing carbon dioxide production rates. Using this information the rate of cellular respiration and total carbon dioxide produced were able to be calculated for all of the preceding experiments, shown in Figure 3.

Discussion

There was an anticipated outcome for each of the two parts of this experiment. It was predicted that the first part of the experiment, where we tested the carbon dioxide produced for both the combination of yeast and water and the combination of yeast, sugar, and water would result in yeast yielding a higher amount of carbon dioxide and therefore undergoing a faster rate of cellular respiration when a carbohydrate (sugar), is present. Our results for this section of the experiment supported this hypothesis, as during the observation period the mixture of yeast and water did not produce any carbon dioxide at all, and therefore did not undergo cellular respiration. At the same time, the mixture of yeast, sugar, and water began to increase around five minutes in, with an end product of one and one tenths carbon dioxide produced.

Pertaining to the second half of the experiment, it was anticipated that yeast would yield much lower quantities of carbon dioxide, and produce carbon dioxide much more slowly in the presence of a carbohydrate and a natural or synthesized pollutant, indicating a lower rate of cellular respiration. This was supported by our findings, as the infected mixtures with a present carbohydrate produced carbon dioxide at a much smaller rate overall then the unpolluted mixture with a present carbohydrate from the first half of the experiment. Three mixtures with pollutants (baking soda solution, isopropyl alcohol, vinegar) saw no cellular respiration at all in the time allotted, although the carbohydrate was still present. In the first half of the experiment, the unpolluted mixture with a present carbohydrate began to see growth around the five minute mark. All of the polluted mixtures that produced carbon dioxide, except bleach and the salt solution, began producing after the five minute mark. The salt solution spiked irregularly early, indicating a probable error in experimental procedure, in light of the fact yeast does not tend to begin cellular respiration within the first minute of being exposed to water and some form of carbohydrate. The bleach solution began producing similarly to the first, unpolluted mixture with carbohydrate, but in the end resulted in a three tenths drop in production from the original mixture, yielding only eight tenths of carbon dioxide.

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