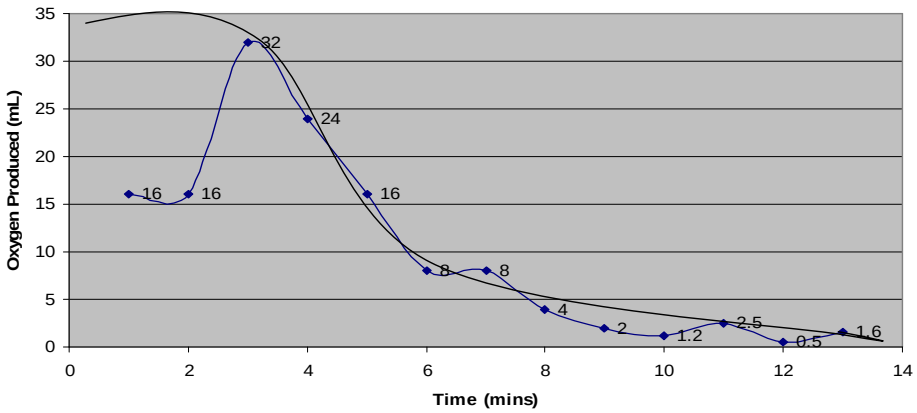
Reactivity of Catalase Enzyme and Hydrogen Peroxide

Summary: My group and I observed certain properties of catalase to determine whether biological enzymes actually participate in chemical reactions or simply facilitate them by providing lower activation energies. We did this by measuring the rate of the reaction of dilute hydrogen peroxide (H_2O_2) in the presence of the catalase enzyme to form of water (H_2O) and oxygen gas (O_2). Our results showed that while catalase does not react with hydrogen peroxide, it does greatly assist in the reaction moving forward. This is consistent with the general knowledge that enzymes are biological catalysts that, by fitting around molecules and stressing particular chemical bonds, facilitate chemical reactions *(Raven et al., 2008)*. Also, other scientific experiments have shown that, by bringing hydrogen peroxide and catalase into contact with one another, an increased amount of reactivity takes place *(Tate et al., 1995)*.

Methods & Results: My group and I began the experiment by constructing a respirometer out of a 150mL Erlenmeyer flask, a rubber stopper with a hole in it, and a 5mL pipette. The flask was filled with 50mL of 3% hydrogen peroxide (H_2O_2) solution in water and then placed in a ~23°C water bath to keep it at a relatively constant temperature throughout. For the catalase enzyme, 2mL of pure liver homogenate was diluted to 10% concentration by combining it with 18mL of water in a test tube and then thoroughly mixing the two together.

To begin, we placed ~1mL of dilute liver homogenate into the flask and then immediately sealed it off with the rubber stopper and pipette. A sudden and somewhat violent reaction occurred: oxygen gas products began forming rapidly, which increased the pressure in the flask and caused the mixture to rise very quickly inside the pipette. In order to prevent overflow, we "burped" the flask as the liquid reached the 5+1mL mark on the pipette and then allowed it to drain. Because there was additional loss of oxygen during this time, we decided to add 1mL extra of measured O_2 for each "burp", meaning that an amount of ~7mL of total gas was measured. We continued this process for 13 minutes and recorded the number of burps and/or mL readings on the pipette individually for each minute. This produced the following chart of data:



The orange line shows recorded data, which is mostly consistent except for the first three minutes. The green line shows a more plausible trend during the course of the experiment, where the initial reaction is strong and eventually slows as the hydrogen peroxide is used up. The amount of dilute liver homogenate appeared to be the same, confirming that the observed reaction was either initiated or accelerated by its presence. Adding more H_2O_2 would have produced results similar to when catalase was added at the beginning of the experiment, as a ready supply of reactants would have once again become available. Our conclusion is that the biological enzyme catalase provides a much lower activation energy for the reaction $H_2O_2 \longrightarrow H_2O + O_2$, but is not actually consumed in this process.

Re*ferences:*
Raven, P. & Johnson, G. & Losos, J. & Mason, K. & Singer, S., 2008. *Biology*, 8th ed., McGraw-Hill.
Tate Jr., D.J. & Miceli, M.V. & Newsome, D.A., 1995. Phagocytosis and H_2O_2 Induce Catalase and Metallothionein Gene Expression in Human Retinal Pigment Epithelial Cells, *Investigative Ophthalmology & Visual Science*, 36(7), pp. 1271-1279.