CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)

Peter L. Zhan

Project Number

S1730

Project Title

Quantitative Analysis of the Effect of Temperature on Bacterial Growth Rates

Abstract

Objectives/Goals

The purpose of this experiment was to mathematically analyze the influence of temperature on bacterial growth using fundamental chemical and statistical principles.

Methods/Materials

In my experiment, I incubated E. coli at various temperatures. All E. coli used came from a common stock. At various times, I measured the optical density (OD) of the cultures. By performing nonlinear regressions, I obtained the growth rate constants at different temperatures. I only included data from the exponential growth phase. I then analyzed the correlation between expected growth rate constants based on the Arrhenius equation and observed growth rate constants.

Results

The observed k values, per hour, at 11°C, 18°C, 28°C, 37°C, 41°C, and 43°C were, respectively, .016122, .07386, .3675, .43338, .40764, and .25836. In comparison to the graphs of the simulated growth rate constants calculated using Q(10) values of 1.2 and 3, the graph of the observed growth rate constants had much steeper slopes. Although there was a relatively poor correlation between the observed k values and simulated k values because of uncorrelated k above the critical temperature for E. coli, Spearman rank correlation analysis of the observed and simulated k at temperatures below the critical temperature reveals a perfect monotonic relationship between the observed and simulated k.

Conclusions/Discussion

Three major conclusions may be drawn from my data. First, at low temperatures, bacteria significantly upregulate their metabolic rate; their growth rate constant k is much larger than the predicted rate based on simple chemical principles. Second, below optimal temperatures, both the growth rate constant and the chemical reaction rate constant increase as temperature increases, albeit at different rates. Third, bacteria are significantly more susceptible to temperature changes than are chemical reactions. These findings are particularly alarming as we face global warming, as even relatively small increases in temperature in any temperature range pose risks to the delicate nature of life's regulatory abilities.

Summary Statement

Using fundamental chemical and statistical principles, I analyzed the influence of temperature on bacterial growth.

Help Received

My AP Statistics teacher Andrea Gould and AP Chemistry teacher Kevin Doyle sponsored and reviewed my project. My father, Dr. Hangjun Zhan, helped me procure some of the necessary materials and supervised my instrument usage.