Predicting the Outcome of Evolution of Bacteria
ELE282, Biomedical Engineering Seminar, February 3, 2003

Sareh Rajaee
Biomedical Engineering, University of Rhode Island
Kingston, RI 02881

Antibiotics have often been thought of as "wonder drugs" of the twentieth century, due to their success in treating several dangerous illnesses caused by bacteria. The discovery of Penicillin, the first antibiotic, both revolutionized and transformed medical care.

Though antibiotics have saved many lives, there lies a longstanding controversy over the long-run damage caused by this medicine. Unfortunately, the extensive and often improper distribution of antibiotics over the past few decades have given rise to a very serious problem: antibiotic resistant microorganisms.

Through the evolutionary process of natural selection, many bacteria have learned to adapt to changes in their environments. As more infectious bacteria become resistant, the antibiotics that could at one point destroy them, are rendered ineffective.

Natural selection is defined as the process that results in the adaptation of an organism to its environment through the means of selectively reproducing changes in its genotype. Natural selection is a result of evolutionary pressures and mutations in genetic sequence. Antibiotics are an example of an evolutionary pressure that is placed on bacteria. Often times, antibiotics only manage to kill the most susceptible bacteria, leaving the resistant bacteria as survivors. The surviving bacteria then reproduce quickly and thrive, transferring resistance on to future generations.

Biomedical engineers have developed a computer model that predicts the evolution of one strain of a common bacterium over hundreds of generations. Bernhard Palsson, Ph. D., of the University of California, San Diego, used the model to determine how well the bacterium would adapt to a specific change in its environment.

Palsson used mathematics and computer simulations to display the interaction of genes and the proteins they produce, to control the functions of living cells. He modeled a strain of E.coli, by allowing the bacteria to grow on glycerol, a metabolite, for a period of two months. During this period, the E.coli population went through 700 generations of natural selection.

Palsson successfully predicted that given time to evolve, the bacteria would achieve an optimal growth rate with the new metabolite. He then used the computer model to predict what the actual growth rate would be.

The results of Palsson's experiments suggest the possibility of computer-aided design and testing of bacteria to improve their metabolic activity before growing them. Though the idea of combating drug-resistant bacteria requires further exploration, there are many promising applications of computer-aided design. Some of these applications include: designing cells to perform useful tasks in bioremediation, protein production, and the production of bio-fuels; improving the design of pharmaceutical products and detergents; and predicting phenotypes based on genotypes.

References:

"Excherichia coli K-12 undergoes adaptive evolution to achieve in silico predicted optimal growth," by Rafael U. Ibarra, Jeremy S. Edwards, and Bernhard O. Palsson, **Nature** | Volume 420 | 14 November 2002 (p. 186-190)

"UCSD bioengineers use computer model to predict evolution of bacteria," www.eurekalert.org/pub_releases/2002-11/uoc--ubu112002.php

"UD chemical engineering professor find bacteria cells progress toward optimal behavior," by Neil Thomas. www.udel.edu/PR/Udaily/2003/edwards011003.html

"Computer Model Predicts the Outcome of Evolution in Bacteria."
www.whitaker.org/news/palsson2.html