CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
Geoffrey H. Woo

Project Number
S1422

Project Title
The Effects of Piezoelectric Ultrasound on the Transportation of Molecules across Membranes

Abstract

Objectives/Goals
In this project, cavitation and pressure created by ultrasonic acoustic waves were hypothesized to increase the transfer rate of molecules even if they normally would not cross membranes. By increasing the wattage levels controlling these mechanisms, the rate was thought to be directly increased. The goal of the experimentation was to determine if piezoelectric ultrasound was an effective mechanism for driving particles under biological conditions.

Methods/Materials
Ultrasound was applied to a variety of different sized molecules, forcing them through a selection of membranes with biological pore sizes. The transfer rates for different molecules were determined by measuring the amount of resulting fluids under various wattage levels for three minutes. By comparing un-powered particle transfer to transfer with various levels of acoustic power, the efficacy and trends of ultrasound-induced acceleration of particle movement could be observed.

Results
The results of the experiment showed that ultrasound was able to increase the transfer rate of fluids in all cases and also forced specific molecules through membranes when normally it was not possible. The rate of transfer for larger molecules leveled off at higher wattages while the rate for smaller molecules continued linearly. Additionally, piezoelectric ultrasound increased particle movement, even in wattage levels below the cavitation threshold.

Conclusions/Discussion
The experiment showed that piezoelectric ultrasound is effective but has limits in accelerating particles across membranes. Moreover, the pressure from acoustic waves, not cavitation, was found to be the main mechanism for particle acceleration. This is significant since sustained cavitation generates great amounts of heat, thus causing unintentional membrane damage. Ultrasound was shown to be a potentially efficient and non-invasive tool for driving nutrients or medicine into a biological system.

Summary Statement
Ultrasound generated by piezoelectric transducers was determined to be a potentially effective and non-invasive tool for driving molecules across membranes into biological systems.

Help Received
Used lab equipment at UCLA under the supervision of Dr. Putterman