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UK Undergraduate Research Program

The UK Undergraduate Research Program is intended to offer students, particularly in their first and second years, the opportunity to begin to engage in research and scholarship with a faculty mentor. Students in this program may enroll in a special research methods course designed to provide them with practical research and scholarship knowledge, such as how and where to seek funding, how grants are administered, using library and Internet resources effectively for research, and writing research and scholarly abstracts and reports. The following abstracts were the final papers submitted by three students who took this methods course in the Spring of 2003 and reported on their on-going research:

Determining Cotton Fiber Quality by Polarized Laser
Aydin Hatemi, Research Assistant to Dr. Mustafa Aslan

I am participating in a detailed experimental/theoretical study on understanding the fundamental nature of individual cotton fibers from a light scattering experiment. In this study, my mentor, Dr. Mustafa Aslan, identified a new methodology to determine the scattering characteristics of irregularly shaped particles, such as cotton fibers.

In the increasingly competitive textile market today, the quality of raw material, such as the quality of cotton, is one of the most important factors for determining the quality of manufactured goods. Therefore, it is essential for textile manufacturers to determine cotton fiber properties, such as fineness, maturity, color, strength, and length and, therefore, processing performance. For this purpose, we built a new precision measuring instrument to picture (profile) the quality (fineness) of cotton fibers.

There are already a few characterization techniques that are used in cotton agriculture. Unfortunately, successful applications of these techniques in agriculture are often valid only for characterization of regularly shaped particles. During the last decade, by using the elliptically polarized light scattering concept, regularly shaped spherical and cylindrical particles have been investigated. This approach is based on the measurement of the scattering matrix elements of single scatters. However, all of the data available for scattering matrix elements is currently limited to regularly shaped particles, and the fundamental nature of fibers cannot be determined from such techniques.

In the case of irregularly shaped micro-scale particles, such as cotton fibers, we have to determine the characterization of particles by using another method. In this research, we developed a rigorous experimental/theoretical approach to determining the radiative properties of single cotton fibers and to correlating these results with cotton properties, particularly with fineness. For this purpose, we designed and built a versatile light source. Detailed polarized-light was sent into six different cotton fiber samples. Then we scanned scattered light from the fibers. We monitored the scattering light on laser sensitive films. These results were compared against the predictions from a finite element model (FEM). Finally, differences between the theoretical and experimental findings were compared.

In this research, we found that knowledge of cotton fiber properties, such as fineness, length, and uniformity, can be determined better than in most of the previous studies on cotton fibers. This experimental study is being expanded to make polarized-light scattering measurements on cotton fibers. Such measurement will allow us to determine the scattering elements, which are expected to reveal more information about the nature and structure of cotton fibers.

A Reexamination of Iran’s Role in the Middle East
Ben Woodman, Research Assistant to Dr. John Stempel

The United States of America has entered a new era of foreign relations. The years following the end of the Cold War held few feelings of unrest among the American people, and a time of relative security was experienced. The September 11, 2001, terrorist attacks on the World Trade Center in New York dramatically changed our country. The attacks gave a new focus to United States’ history, and we are forced to reexamine the way that we deal with other countries, particularly Islamic nations.

The study in which I have assisted Dr. John Stempel has focused on a nation that has been at odds with the United States of America since 1979, the Islamic Republic of Iran.

Dr. Stempel served as the Deputy Chief of the Political Section of the American Embassy in Tehran from 1975 until the nation’s revolution five years later. This, in addition to the rest of his career in diplomacy, has allowed Dr. Stempel to obtain considerable insight into the complex structure of Middle Eastern political systems, particularly that of the Iranians.

My responsibility has been to gather information and prepare it for Dr. Stempel. Using a wide range of sources such as census figures, economic analyses and forecasts, academic journal pieces, and Iranian news lines, I was able to find relevant data and brief the information’s main points for submission to Dr. Stempel, as well as create outlines showing important information and my own viewpoints. The research that we have conducted this year has been the basis for a series of written and oral discussions of Iran’s foreign policy and how our own nation’s decisions can affect it. The study will also become part of a
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broader study of the United States’ options in the Middle East for the Council on Foreign Relations and the U.S. State Department.

In recent times, our country’s dealings with Islamic countries have had to undergo some re-thinking. Our policies in the Middle East are becoming increasingly unpopular among Moslems, and under the threat of Islamic extremism we can no longer ignore the potential problems that can arise from the area.

Our work is geared to show the massive amount of evidence that points to Iran being the catalyst that could lead to improved US-Islamic relations and be a giant leap in stamping out terrorism. The aim of the study is to show that the US can no longer afford to ignore Iran in the ways it has since the hostage takeover. In the written discussions from our study, Dr. Stempel concludes that the stubborn approach that the US has taken toward the Islamic Republic has led to our poor relations. An example of this is the Clinton administration’s refusal to finalize the creation of a deal between AMOCO and the North Iranian Oil Company. Another example was President George W. Bush’s classifying the country as part of the “Axis of Evil” with Iraq and North Korea, further inflaming the anti-American sentiment in Iran.

The point that our work makes is that Iran holds many key elements for change: a disproportionately young population, an easily expandable economy, and a growing level of dissatisfaction with the current state of affairs within the country. Iran has already begun modernizing its economy via new trade agreements with the European Union. These agreements have not only helped the country take steps toward economic modernity, but have led to social reforms such as a moratorium on death sentences by stoning. These agreements benefit not only Iran, but also the EU, supplying it with much needed oil. Such progress could also be accomplished with cooperation with the US, and this could help to end the bitter relations our countries have had.

Strategically, Iran is a gold mine. Iran has one of the Middle East’s largest populations with a high degree of support for reform and modernization, and Iran is the main supplier to militant groups such as Hamas and Hezbollah. The US could potentially boost Iran’s economy by lifting current sanctions, and Iran is next-door to the US’ current project in the Middle East, Iraq. The bottom line is that our policies toward Iran need to weigh the importance of a political grudge against the possibilities of gaining a new oil-trade partner, cutting off supply lines of anti-Israeli terrorist groups, obtaining valuable co-operation with a soon-to-be nuclear power, and giving our image a much needed improvement in the minds of Moslems. Iran is far too important to ignore, and, though it will take large concessions on both sides, the benefits outweigh the costs.

Modulation of DRG Neurite Morphology
Brandon Sutton, Research Assistant to Dr. Philip Bonner

Introduction and Background

Motor neurons generate action potentials and propagate them to the axon tips that contain pre-synaptic vesicles. The impulse causes these vesicles to fuse with the cell membrane and release acetylcholine into the synaptic cleft. Here, acetylcholine attaches to the nicotinic acetylcholine receptor, which is a ligand gated Na⁺ channel located on the muscle cell. The opening of this channel ultimately causes the muscle to contract. Because not all of the acetylcholine that has been released is used, it either degrades in the cleft or becomes bound to nicotinic acetylcholine receptors that lie on the presynaptic cell.

In motor neurons such as these, it has been observed that when an axon loses its ability to interact with a muscle cell it will branch out in search of a new connection. Once this new connection has been established, the cell can resume its normal function. Axon branching in response to interrupted synaptic transmitter release has been observed after experimental manipulations such as axotomy, inhibition of action potential propagation, and blockade of neurotransmitter release by botulinum toxin type A. It has been suggested that the nerve cell membrane, especially the pre-synaptic portion, contains acetylcholine receptors that act like regulators to tell the cell that transmitter is being released at the synapse.

In my research, I examined a group of neurons that are not motor neurons but are part of the somatosensory system. Dorsal root ganglia (DRG) lie on the sides of the spinal column and connect the peripheral nerves with the spinal cord. In these experiments, DRGs are extracted from 9- and 10-day chick embryos and observed in vitro in response to the addition of alpha conotoxin MII, a highly specific snail-derived protein that binds to the α3β2 nicotinic acetylcholine receptor. When this binding occurs, acetylcholine is no longer able to bind, therefore the receptor Ca⁺ channel remains closed. Camera lucida drawings were made of the neurons so that axon growth and branching characteristics could be analyzed.

Methodology

These experiments were carried out by first obtaining 9-10 day chick embryos and then extracting them from their shell for surgical manipulation. The dissection of the DRGs was carried out under a light microscope in 10-15mL of calcium-magnesium free (CMF) saline solution. The DRGs were extracted from the embryos and transferred to 1 mL FM culture medium. The ganglia were then pulled through a 26 gauge needle of a 1cc syringe 3-5 times to dissociate the ganglia into single cells. Approximately 0.15 mL of the solution
containing the neurons was then placed on 60mm plastic Petri dishes that had previously been coated with ECM Gel (diluted 1:10 with water and dried) and contained 2.5mL of culture medium. Then the dishes were either set aside for controls or 12.5μL of 50nM Alpha conotoxin MII was added directly to the medium. The plates were then placed in an incubator for approximately 24 hrs. and then examined under 400X magnification and the neuron morphologies recorded through camera lucida drawings. The drawings were later analyzed for branching frequencies and neurite lengths.

Conclusions
- Alpha Conotoxin MII increases neurite branching in dorsal root ganglion neurons.
- The specific binding nature of conotoxin MII indicates the α3β2 nicotinic acetylcholine receptor is present in DRGs and is possibly being used to monitor and regulate neurite branching of these neurons.
- The total length of the DRG neurites of conotoxin treated cells are much longer than control cells. This indicates that the rate of neurite elongation at the growth cones is not significantly inhibited by the increased branching caused by conotoxin.

Future Objectives
The manipulation of morphologies of DRGs and other types of neurons have been accomplished through the use of compounds such as conotoxin and botulinum toxin in in vitro experiments. The next step is to introduce these compounds into a living organism to observe their effects.

Currently, new experiments have started involving the administration of botulinum toxin into an E-13 embryo after a cervical spinal cord crush. The embryo is allowed to develop for three days and then is fixed, sectioned, and stained for observation. Preliminary data suggest that DRGs in embryos treated with botulinum toxin have a greater number of axons entering into the spinal cord than DRGs of control animals. E-16 embryos treated with botulinum toxin had a total number of axons entering the spinal cord from a DRG of 215 ± 11.17, while control embryos had a lower average of 179 ± 49.87.

In addition to the in vivo and in vitro correlation of the effects of botulinum toxin on DRGs, the current experiments are also being used to examine the effects of botulinum toxin on spinal cord neurons around the site of the crush to determine the potential regenerative capabilities of botulinum toxin.