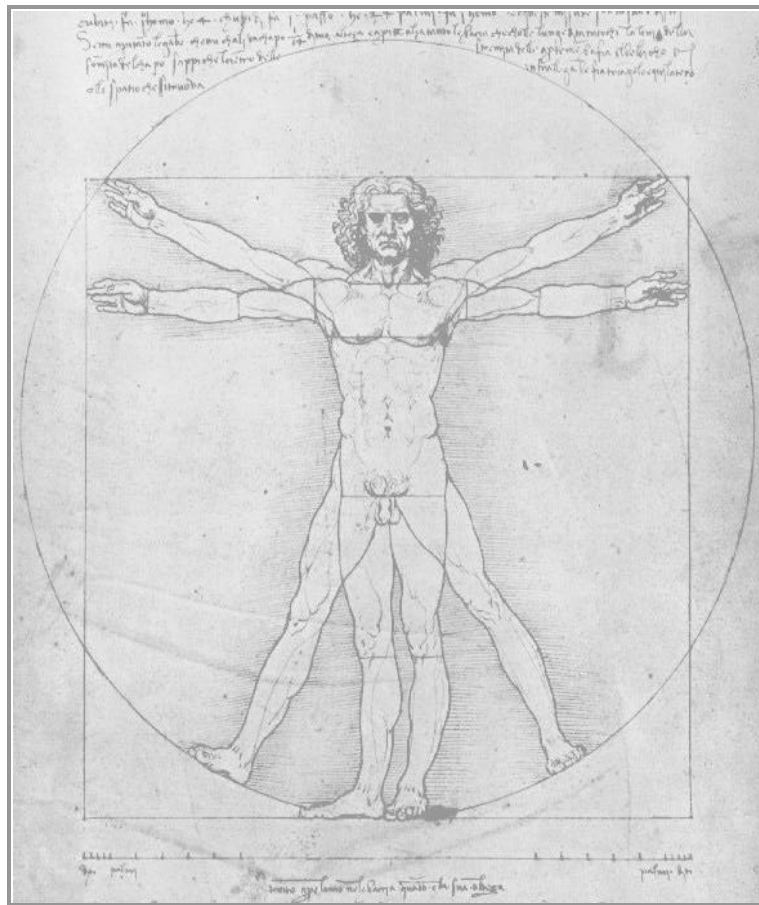


**Department of Biomedical Engineering
Tulane University**

**Biomedical Engineering Undergraduate
Research and Design Conference**



Conference Proceedings

January 24, 2003

**Department Of Biomedical Engineering
Tulane University**

**Biomedical Engineering Undergraduate
Research and Design Conference**

Conference Proceedings

January 24, 2003

Welcome to the *1st Annual Biomedical Engineering Undergraduate Research and Design Conference!*

Tulane University is one of just 20 of the nation's private, A.A.U., Carnegie 'Research Extensive' Universities with a school of engineering. Twelve of those 20 have undergraduate programs or departments of Biomedical Engineering, and Tulane University is one of only seven with an ABET accredited department. The department evolved from joint research efforts among faculty in the School of Engineering and the Schools of Medicine at Tulane and the Louisiana State University Medical Center in New Orleans. Research interests led to educational programs, and undergraduate BMEN degrees were first awarded at Tulane in 1972. In 1977 a separate Department of Biomedical Engineering was formed in the School of Engineering to offer the B.S., M.S., and Ph.D. degrees.

The undergraduate program, ABET accredited since 1981, is now the largest major in the School of Engineering with approximately 175 undergraduates and 40 graduate students; courses and research are focused in five 'domains' of biomedical engineering: biomechanics, bioelectronics, bioelectricity, biomaterials, and cell and tissue engineering. As one of the largest and most highly acclaimed departments in the country, our faculty and students have pioneered many of the curricular innovations that set the standard for educational excellence in this exciting and rapidly growing field. Our commitment to provide opportunities to learn in a manner comparable to that in which learning will take place when practicing as a biomedical engineer sets us apart from our colleagues in the nation's university community.

As is common for all engineering disciplines, our students have participated in a ***required team design project*** since the department's founding in 1977. Since 1987, these projects have all been related to assistive technology for local individuals with specialized needs. Biomedical Engineering students work on these designs during their senior year, culminating in a public design show in the spring.

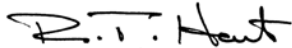
However, ***unique among the nation's departments of Biomedical Engineering***, all Biomedical Engineering undergraduates have also participated in a ***required year-long independent research or design project*** since the department's founding in 1977. Students work with departmental faculty mentors or our counterparts throughout Tulane and at affiliated institutions in the New Orleans area and across the nation. The projects are not merely academic exercises, but genuine and significant contributions to the field of biomedical engineering, complete with scholarly theses and, in many instances, peer-reviewed publications.

Until this year, the presentation of their independent projects has occurred during the Department's Spring Semester Seminar Series. For the first time, this year we have chosen a presentation format modeled on a professional research conference. The presentations to follow represent in a few minutes what has taken each countless hours in the research or design laboratory to execute. This conference presentation is thus the punctuating culmination of a sustained effort of scholarship worthy of admiration at the highest levels.

We are hopeful that this conference highlighting the efforts and results of our undergraduates will serve to communicate the excitement and potential of the field to the larger university community.

As you look at the conference proceedings and attend the talks, I'm certain that you will be astounded by the breadth and depth of the educational experience each of our students has accomplished, and I hope you will be excited about their potential as they prepare to graduate this Spring and begin to make their marks as leaders in the field of biomedical engineering. We think you will agree that congratulations are due the members of the Biomedical Engineering Class of 2003 for their achievements, achievements that truly set them apart.

Thank you for attending!

A handwritten signature in black ink, appearing to read "R. T. Hart". The signature is written in a cursive style with some capital letters.

Richard T. Hart. Ph.D.

Alden J. 'Doc' Laborde Professor and Department Chair of Biomedical Engineering

Departmental Vision

The Department of Biomedical Engineering is committed to being a global leader in biomedical engineering scholarship. Our faculty, staff, and students are all important parts of the team that will complete our missions of: excellence in undergraduate and graduate education; meaningful and innovative research; and service dedicated to advancing the field of Biomedical Engineering.

Conference At A Glance

8:45 AM Welcome: University Center, Stibbs A&B

Dr. Richard T. Hart

Alden Laborde Professor and Chair, Biomedical Engineering

9:00 AM Morning Session A: University Center, Stibbs A&B

Session Co-Chairs: Dr. Francis Suh, Dr. Natalia Trayanova

- 9:00-9:15 *A Comparison Between Current Research In The Field Of Injury Prevention In Automobile Accidents, Related Government Standards And Rating Systems, And Safety Regulations In Racing Cars*
Daniel A. Palmer
- 9:15-9:30 *Experimental Investigation of the Hydraulic Permeability in Fixed Porcine Brain Tissue*
Jeff Ventimiglia
- 9:30-9:45 *A Comparative Study Of Viscoelastic And Biphasic Poroviscoelastic Computational Models Of The Brain For Simulating Traumatic Injury*
Joseph E. Olberding
- 9:45-10:00 *The Effects Of Alcohol On The Magnitudes And Frequencies Of Brain Waves*
Julien Prevost
- 10:00-10:15 *Computational Thermal Model For The Development Of Thermoelectric Cooling Of Peripheral Nerve*
Andrew G. Voyiadjis
- 10:15-10:30 Coffee Break
- 10:30-10:45 *A Look Into Post-Shock Filament Dynamics*
Carlos Haro
- 10:45-11:00 *Improvement Of A Glaucoma Drainage Device With a Pressure Chamber Based On The Principle Of A Starling Resistor*
Erika F. Jordan
- 11:00-11:15 *Determination Of The Mechanical Properties Of Diabetic Coronary Arteries By Intravascular Ultrasound*
Can Yaman
- 11:15-11:30 *Airway Reopening; The Propagation Of Air Fingers Into Elastic, Fluid-Filled Tubes*
Bradford Smith
- 11:30-12:45 Lunch (not provided)

9:00 AM Morning Session B: University Center, Presidents Room A&B
Session Co-Chairs: Dr. David Rice, Dr. Kay C Dee

- 9:00-9:15 *Validation Of The Existence Of "Spore-Like" Stem Cells*
Megan Kaneda
- 9:15-9:30 *Verification and Characterization Of "Spore-Like" Cells In Rats*
Jennifer Berumen
- 9:30-9:45 *Refinement Of Cornea Organ Culture To Determine Rates Of
Epithelial Defect Closure*
Margo Snyder
- 9:45-10:00 *A Design Of A Device To Isolate Mesenchymal Stem Cells From Bone Marrow*
Meghana Kamath
- 10:00-10:15 *Development Of An Umbilical Cord Blood-Derived Fibrin Gel For 3-D Neural Grafts*
Matthew A. Struck
- 10:15-10:30 Coffee Break
- 10:30-10:45 *Surgeon Hand Tremor*
Scott Wheeler
- 10:45-11:00 *The Use Of Personal Digital Assistants To Increase The
Medication Compliance In The Elderly*
Justin Guay
- 11:00-11:15 *Design And Implementation Of A Wireless Data Acquisition System*
Jorge Nagel
- 11:15-11:30 *Engineering Management: A Proposal For Tulane University*
Odelya Levy
- 11:30-12:45 Lunch (not provided)

1:00 PM Afternoon Session A: University Center, Stibbs A&B
Session Co-Chairs: Dr. Kirk Bundy, Dr. Glen Livesay

- 1:00-1:15 *Creation of a Tissue-Engineered Soft Tissue-Hard Tissue Interface Through Cytokine Diffusion*
Darryl A. Dickerson
- 1:15-1:30 *Three-Dimensional Characterization Of A Normal Soft Tissue To Hard Tissue Entheses*
Alycia Wanat
- 1:30-1:45 *Multi-Axial Functional Evaluation Of The Normal Anterior Cruciate Ligament And Replacement Graft*
Kevin Wasco
- 1:45-2:00 *Acoustic Characteristics And Mechanical Properties Of Articular Cartilage And Its Major Molecular Components*
Aston Oldendorf
- 2:00-2:15 *A Device To Evaluate The Mechanical Properties Of Biological Tissues In Tension*
Amber Williams
- 2:15-2:30 Coffee Break
- 2:30-2:45 *Automated Analysis Of Macular Degeneration*
Curtis M. Humphrey
- 2:45-3:00 *Studies Of Enzyme Inhibition Biosensors For Applications In Natural Environments And In Vivo*
Richard D. Collier III
- 3:00-3:15 *A Comparative Study Of Devices To Detect Herpes Simplex Virus By Quantitative Real-Time Polymerase Chain Reaction*
Erin C. Riley
- 3:15-3:30 *The Extraction Of McKrae-EGFP HSV-1 Cells Via Laser Microdissection*
Michael J. Ryan
- 3:30-3:45 *Verification Of Assumptions Used In Determining Corneal Cell Adhesion To Hydrogels With A Jet Impingement Method*
Albert Stoltz

1:00 PM Afternoon Session B: University Center, Presidents Room A&B
Session Chair: Dr. Cedric Walker, Dr. Eric Nauman

- 1:00-1:15 *Mechanical Testing Of Athletic Shoe Cushioning Systems For Optimized Performance*
Luke Hooper
- 1:15-1:30 *An Investigation of Forced-Use And TENS Treatments For Childhood Hemiparesis*
Susan Zawaski
- 1:30-1:45 *Design Of A Forced-Use Treatment Restraint For Children With Hemiparesis*
Lorey Flick
- 1:45-2:00 *A Device And Method Of Gait Analysis For Diabetic Neuropathy*
Michael Palazzolo
- 2:00-2:15 *Development Of A Computer Model Of Aircraft Flight For Use In Flight Control Systems*
Casey J. Ronayne
- 2:15-2:30 Coffee Break
- 2:30-2:45 *A Dynamic Model Of Calcium Homeostasis In The Body*
Jayna M. Belt
- 2:45-3:00 *Mechanical Analysis And Bone Adaptation In Scoliotic Spines*
Sara Rumancik
- 3:00-3:15 *Bone Adaptation In The Scoliotic Spine With Osteoporosis*
Robert H. Routh
- 3:15-3:30 *Assessment Of Morphological Variation In A Human Femur*
Melissa M. Banitt
- 3:30-3:45 *Extending Morphologic Analysis To Include Whole Joints: Preliminary Application To The Knee*
Megan M. Mickal

4:00 PM Post-Conference Reception, Faculty Dining Room, 2nd floor of the University Center

**Department Of Biomedical Engineering
Tulane University**

**Biomedical Engineering Undergraduate
Research and Design Conference**

Conference Abstracts

Morning Session A

A Comparison Between Current Research in the Field of Injury Prevention in Automobile Accidents, Related Government Standards and Rating Systems, and Safety Regulations in Racing Cars

Daniel A. Palmer

Advisor: J.K. Francis Suh, Ph.D.

In the past few decades, automobile safety has advanced greatly, both on the track and on the street. Ideally there would be a fair amount of crossover from race proven cutting edge into the cars that we drive. There has also been a good deal of research carried out at universities, by manufacturers, and by other parties, in the field of injury prevention in automobile accidents. With the ever-increasing mobility of the country, more accidents are going to happen. This paper will take a general look at three areas, racecar safety, passenger car safety, and current research in the field with a focus on biomechanics. A comparison will be made in order to assess if racing safety technology is being carried over and if current research is being applied by the manufacturers and enforced by the Government. This will produce a good overview of the state of the industry and safety on the highway and the racetrack.

The comparison of the various materials uncovered discrepancies in the regulations of passenger cars and racecars as well as the knowledge available in the literature. Most of the research supported the current regulations but an examination of past regulations showed the time it took to translate new technology into a new requirement. There were a few obvious differences though. Most of the research could not be applied to racing formulas and those that could, matched up nicely with the regulations found there. The racing car and passenger car regulations were very similar but the F1 cars had more stringent minimums and maximums allowed.

The facts were examined and some conclusions were drawn to explain these discrepancies. In terms of safety in passenger cars lacking in comparison to racing cars, factors like high price, lack of consumer involvement, and the controlled racing environment make most crossover of technology here irrelevant. In terms of application of research to passenger cars, the high price passed onto the consumer, and the pathways involved with changing Government regulations are the chief culprits.

Research for this Project Conducted at Tulane University.

Experimental Investigation of the Hydraulic Permeability in Fixed Porcine Brain Tissue
Jeff Ventimiglia
Advisor: Francis Suh, Ph.D.

Over the past decade computer models have been used to simulate and model brain injury and drug delivery systems. Although these computational models have increased the field's knowledge, they have lacked certain experimental parameters. One of such parameters is the hydraulic permeability of white and gray matter. The purpose of this study was to experimentally find the hydraulic permeability of brain matter and compare these new findings with the theoretical data found previously through computer simulations.

This study used a pressure controlled permeability machine to test samples of fixed porcine brain. The porcine brains were harvested from sacrificed pigs and were allowed to soak in formalin for at least 48 hours before testing. Five samples of both white and gray matter were tested and statistically compared. This system was governed by the permeability equations formulated by French Scientist Henri Darcy.

After the samples have been tested the hydraulic permeability was found using Darcy's law of permeation. The hydraulic permeability of White and Gray matter was found to be

7.89 ± 5.50 (mean \pm S.D.) $\times 10^{-13}$, 2.03 ± 1.24 (mean \pm S.D.) $\times 10^{-12}$ [m^4/Ns], respectively. Graphical analysis of this data has shown that the permeability of these specimens was linear.

These results show that the previous theoretical studies were fundamentally wrong in their assessment of brain permeability. This study was the first of its kind and shows that, unlike previous convention, that gray matter is more permeable than white matter and that computational models have been using unreliable data to understand brain injury and drug delivery. This study has given another experimental parameter to the theoretical studies of brain simulation.

This project was conducted with support from the Department of Biomedical Engineering.

A Comparative Study of Viscoelastic and Biphasic Poroviscoelastic Computational Models of the Brain for Simulating Traumatic Injury

Joseph E. Olberding

Advisor: J-K Francis Suh, Ph.D.; Co-advisors: Glen Livesay, Ph.D., Eric Nauman, Ph.D.

Traumatic brain injury (TBI) is a serious and debilitating condition with diverse causes and consequences. Much research over the years has used both animal and physical models to study head and brain trauma, but with little incorporation of analytic mathematical methods. Studies that do use the finite element (FE) method often feature complex and accurate three-dimensional geometries of the brain and accessory organs, but model brain tissue as simply a viscoelastic (VE) solid. However, it has been shown that biological soft-tissue is best described by the biphasic poroviscoelastic (BPVE) theory in which there is continuum mixture of an extracellular solid matrix perfused with an interstitial fluid. The mechanical behavior of the tissue under loading is then a function of both the individual solid and fluid phases as well as the interactions between them. Our lab has recently developed dynamic FE BPVE software suitable for simulating brain impact. The objective of the present study was to compare the behavior of VE and BPVE computational models of the brain under dynamic loading.

Two simplified circular and parasagittal two-dimensional geometries were employed to model the shape of the brain. The geometries were meshed with eight-node quadrilateral plane strain elements for the VE model and with Q2-P1 mixed elements for the BPVE model. All geometry and mesh generation was conducted using MSC.Patran. Both models assumed isotropic homogeneous composition with material parameters consistent with those reported in literature. The models were subjected to inertia and point loading conditions. The analysis codes used were ABAQUS/Standard and a custom formulation for the VE model and BPVE model, respectively. The FE output was postprocessed using custom applications and Tecplot to extract hydrostatic pressure and maximum shear strain values throughout the meshes and for the time history of the impact event. All preprocessing, FE analysis, and postprocessing were performed on a Silicon Graphics Octane and Origin 2000 workstations.

Under peak inertial loading, both models experienced high positive pressure on the impact side and negative pressure at the opposite pole. For point loading, both models exhibited high positive pressure and shear strain at the site of impact that propagated throughout the brain model. However, in general the VE model showed lower pressure values and higher shear strain values than the BPVE model. Additionally, high relative levels of pressure and shear strain persisted for much longer in the VE model than in the BPVE model.

The higher pressure values in the BPVE model are best explained by the significant fluid pressure contributions inherent in BPVE theory. However, these same fluid flow properties served to hasten the pressure release and damping effect observed in the rapid dissipation of loads in comparison with the VE model. Thus, it was shown that the BPVE model was sufficient in predicting the generally accepted behavior of brain tissue under loading while suggesting several new phenomena that deserve further study.

This project was conducted at the Computational and Experimental Tissue Mechanics Laboratory of the Tulane University Department of Biomedical Engineering.

The Effects of Alcohol on the Magnitudes and Frequencies of Brain Waves
Julien J. F. Prevost
Advisor: Paul L. Nunez, Ph.D.

The effects of alcohol on the human brain have been primarily studied on the scale of synapses and neurons. Little work, however, has been done on the effects of alcohol on the cerebral cortex. EEG recordings measured the electrical potentials at the surface of the cerebral cortex and are strongly related to cognitive and behavioral measures. The purpose of this case study was to determine the effects of alcohol on the magnitude, frequency and coherency of EEG electrical signals.

The data sets of subject R were recorded from a 131 metal electrode electroencephalogram. The measurements were done for two states of consciousness: an eyes-closed waking state and a relaxed / cognitive state. These recordings were produced in two stages: first, without alcohol, and second, with alcohol. The data sets were analyzed using Matlab 6.0. The power spectrum and coherence estimates were extracted from the raw data using Fourier Transform methods. The results are graphed in term of average power spectrum vs. frequency, average coherency vs. frequency and coherency vs. electrode distance. The results are also mapped on a 2-D cerebral cortex in term of average 9-13 Hz bandwidth (alpha band) and average 4-8 Hz bandwidth (theta band) power spectrum and coherence estimates.

In the resting state analysis, the average power spectrum estimate of the data set with alcohol showed a 22% increase in the average theta band magnitude, and a 36% decrease in the average alpha band magnitude compared to the data set without alcohol. The coherence estimate revealed the similar changes, with a 20% increase in the average theta band coherency and a 6% decrease in the average alpha band coherency. The graphs in the relaxed / cognitive states with alcohol showed a shift of the alpha band magnitudes to lower alpha band frequencies, compared to the data set without alcohol, in the average power spectrum and average coherence estimates. The average power spectrum estimate of the data set with alcohol also revealed a 133 % increase in the average theta band magnitude compared to the data set without alcohol for the relaxed and cognitive state. A 28.8% increase in the average theta band magnitude appeared between the relaxed state and the cognitive state. The coherency estimate of the subject with alcohol has a 37.4% increase in the theta band and a decrease of 10% in the alpha band compared to the sober state for both relaxed and cognitive states.

This case study determined some effects of alcohol on the large-scale dynamics of the cerebral cortex. In the resting state, theta band amplitudes and coherency increase and alpha band amplitudes and coherency decrease compared to the sober state. In the relaxed / cognitive state, large increase in the theta band power spectrum occurs compared to the sober state.

Acknowledgement to The Brain Sciences Institute at Melbourne, Australia.

Computational Thermal Model for the Development of Thermoelectric Cooling of Peripheral Nerve

Andrew G. Voyiadjis

Advisor: Dr. Roger Beuerman, Ph.D.

A neuroma is a neurological disorder that is generally characterized as an unmyelinated nerve with a mixture of regenerated axons, Schwann cells, entrapped axon endings, fibroblasts, and connective tissue arranged in a disorganized manner. This disorganization ultimately causes pain to the patient around the neuroma. A small nerve's sensory unit can be drastically affected by a change in temperature, pH, electrical input, or hormones. In this study a thermoelectric cooling module (TEM) will be fitted on an apparatus that is modeled decrease the temperature around a rabbit's nerve containing a neuroma.

The computational model was carried out using Abaqus version 6.3 to determine the thermodynamics of a small environment when a peltier device is used to lower the temperature of the system. Once the device decreases the temperature of the nerve fibers to a certain threshold the multiple stimuli produced by the neuroma will decrease, thereby decreasing the pain caused by the neuroma. This slight decrease in the temperature on the nerve fibers causes Sodium/Potassium recycling to decrease free ion exchange across the pump, which in turn decreases the excitatory postsynaptic pulse summation so that the action potential threshold is not reached, thereby decreasing the pain stimulated by the nerve.

In this study temperature nodal paths were devised along and with the nerve to describe how heat transfer, due to conduction, specific heat, and density, was transformed across the entire nerve during a heat flux out the top of the device. A temperature of ~280 Kelvin (7°C) to ~287 Kelvin (14°C) was uniformly distributed 5 millimeters along the nerve when 0.20 watts of heat was removed from the surface of the device (stainless steel 316L, saline, and nerve). This length is sufficient enough to decrease the electrical activity of the nerve significantly, based on the number of Nodes of Ranvier that the nerve contained within this distance. As the amount of saline within the model was decreased, the amount of heat need to be extracted from the system increased due, in part, to the specific heat of stainless steel 316L. Part of this study was also the construction of a device to be used in a later "in vitro" study of the device's effects on rabbits with neuromas.

In conclusion this study helped give an appropriate range of heat flux for a small system with thermodynamic environmental constraints so that a desired change in temperature is obtained. Likewise, this study helped provide more possible points of engineering problems that can be taken into account in later studies.

This project was conducted at the LSU Eye Center and supported by my senior thesis advisor Dr. Roger Beuerman.

A Look Into Post-Shock Filament Dynamics
Carlos F. Haro
Advisor: Natalia Trayanova, Ph.D.

Coronary Heart Disease has the highest mortality rate in the United States. Around half of these deaths were attributed to ventricular fibrillation (VF). The only known treatment for VF is to apply a defibrillation shock. However, the mechanisms responsible for the success of such a shock remain unknown, rendering this technique inefficient. This is due to the inability of current experimental mapping techniques to visualize the electrical activity in the bulk of the myocardium. Using a realistic rabbit heart model, this study presents the first ever evaluation of the post-shock filament dynamics for both successful and failed shocks.

A high-resolution, three-dimensional, finite element model of the rabbit heart ventricles was constructed. The model incorporated anatomically accurate geometry and fiber architecture, blood-filled cavities, and electroporation. The heart tissue was modeled as a bidomain. Fibrillation was induced by a train of 16 electrical pulses, each having a period of 50 milliseconds and an eight percent duty cycle. Following 600 milliseconds of self-sustained fibrillatory activity, a 9 millisecond monophasic shock, with eight different strengths, was applied between the base and apex of the heart through cuff electrodes. Filament analysis consisted of identifying and examining the filaments, and categorizing them by location (left ventricle, right ventricle, or septum), type (I, O, U, or transitional), and total number of filaments present.

Immediately after the shock (30 milliseconds), the number of filaments was at its largest for all the simulations. This number sharply decreased until 100 milliseconds after the shock. All the filaments completely disappeared within 250 milliseconds of the delivery of a successful shock. On the other hand, the number of filaments began to rise again after 250 milliseconds of an unsuccessful shock. Filaments were only found in the left ventricle after a successful shock. Transitional filaments occurred in the early stages of post-shock activity and died down as the activity evolved. O-type filaments were uncommon after 100 milliseconds of the shock. I-type filaments were predominant after 200 milliseconds of post-shock activity.

The increment of post-shock filaments as shock strength increased can be explained by the tendency of filaments to break up as the shock magnitude increased. However, a high number of these filaments vanished because they were left to evolve in a limited volume of tissue, resulting in annihilation or aggregation of filaments. The combination of different filaments explains why numerous transitional-type filaments were observed early after the shock. Furthermore, O-type filaments were mostly found in the septum; U-type filaments were concentrated in the LV, and I-type filaments were dominant throughout the heart in unsuccessful shocks, especially in the RV.

This project was conducted with support from the Computational Cardiac Electrophysiology Laboratory in the Department of Biomedical Engineering.

Improvement of a Glaucoma Drainage Device With a Pressure Chamber Based on the Principle of a Starling Resistor

Erika Jordan

Advisor: David A. Rice, Ph. D., P.E.

Glaucoma is a disease marked by optic nerve damage. This is usually caused by increased intraocular pressure (IOP) of the eye due to excess aqueous humor fluid in the eye's anterior chamber. If left untreated, the disorder can result in blindness. Glaucoma is currently being treated with medications, laser surgery and as a last resort, glaucoma drainage devices. Many glaucoma drainage devices do not regulate the flow of aqueous humor out of the eye and can cause hypotony or hypertensiveness once implanted. The purpose of this study is to construct a complete prototype of a glaucoma drainage device including a pressure chamber that provides resistance to and regulates flow and pressure. Also, this study aims to show that including a pressure chamber on the design of a glaucoma drainage device works and will be beneficial.

Young's Moduli of different materials were found to help decide which material should be used for the pressure chamber. Three materials, silicone sealant, latex, and a catalyst-cured silicone were tested to calculate Young's Modulus of the materials. Four different mathematical models were developed to demonstrate a relationship between the height of the pressure chamber and the pressure within the chamber. This helped to decide the dimensions of the physical model as well as give us a way to know exactly what the pressure is within the chamber once a certain height has been reached. Finally, a physical model of the pressure chamber was built to test the relationships shown by the mathematical models and to illustrate that the idea of the pressure chamber to regulate flow does work as expected.

The catalyst-cured silicone was the element chosen mainly because of its properties; the material did not stick to it or other materials and was easy to handle. Silicone has been used in other glaucoma drainage devices, while studies have shown that it evokes less of an inflammatory response than additional device materials. The predicted values of pressure from the mathematical model and actual values of pressure from the physical model did not match up as well as expected. The measured values were much higher than the predicted values. Flow testing through the device resulted in observations of the flow rate varying as the chamber pressure changed. Steady flow occurred when chamber pressure was less than the inlet pressure and flow was stopped when chamber pressure was greater than the inlet pressure.

There is still work to be done on the theory behind the mathematical model at a future date. However, the support does demonstrate that a pressure chamber works to regulate flow and pressure through the device. Most importantly, this study shows that a drainage device with a pressure chamber can be used to combat glaucoma.

This project was conducted at Tulane University, Department of Biomedical Engineering.

Determination of the Mechanical Properties of Diabetic Coronary Arteries
by Intravascular Ultrasound

Can Yaman

Advisor: D. Geoffrey Vince, Ph.D.

Diabetes Mellitus is a disease where excess glucose cannot be stored in the body. Insulin is the hormone which controls the storage of excess glucose. There are two types of diabetes, type I and II. In type I diabetes the body cannot produce insulin due to destruction or malfunction of beta cells located in the pancreas. In type II diabetes, insulin is produced but cannot function. Both types have two major complications of in the body, nerve damage and vascular abnormalities. Cardiovascular complication occurs when plaque consisting of fat, cholesterol and other particles form on the walls of arteries. Previous studies have showed that type II diabetic individuals have two to fourfold increased risk of cardiovascular disease compared to non-diabetics. Plaque formation is shown to increase arterial stiffness. Therefore better assessment of biomechanical properties of arteries will result in more accurate medical procedures to avoid complications. The purpose of this study was to determine arterial compliance and modulus of arterial elasticity of diabetic coronary artery specimens and correlate results with non-diabetic coronary arteries, *ex vivo*.

Left anterior descending coronary arteries were statically loaded 7 times from 0 to 260 mmHg and back to 0 mmHg for preconditioning. Then arteries were loaded statically from 0 to 260mmHg. Intravascular ultrasound devices recorded changes in pressure, radius and area. The results were later used to obtain non-linear elastic properties of human coronary artery segments from autopsy material by modified thin-walled cylindrical approach. Then results were used to construct compliance-pressure, modulus-pressure, area-pressure, and radius-pressure curves. The results were also compared with non-diabetic arteries. Thick-walled cylindrical approach was also used to compare wall stress results with thin-walled cylindrical approach results. No difference was found.

Coronary artery middle-wall circumferential stress increased as pressure increased in both groups. Middle-wall circumferential stress values at transluminal pressure of ~100mmHg was 589 ± 116 mmHg for diabetics and 559 ± 143 mmHg for non-diabetics. Compliance tended to decrease as pressure increased. Results were tried fitted by linear, logarithmic and exponential regression curves but it was not successful. Compliance (mm^2/mmHg) at ~110mmHg was 0.00128 and 0.00035 for diabetic and non-diabetic groups, respectively. (All data mean \pm SD)

Incremental elastic moduli were calculated for diabetic and non-diabetic groups. E_{inc} (mmHg (mm/mm)) was $1.00E+04$ and $4.54E+04$ for diabetic and non-diabetic groups, respectively.

More data should be analyzed before concluding that diabetic arteries have less compliance than the non-diabetics.

This research project progressed between the dates May 20th and July 26th, 2002 in Biomedical Engineering Department in Cleveland Clinic Foundation.

Airway Reopening: The Propagation of Air Fingers into Elastic, Fluid-Filled Tubes
Bradford Smith
Advisor: Donald P. Gaver III, Ph.D.

The collapse and subsequent reopening of compliant airways impacts the welfare of a significant number of Americans each year, from premature infants with respiratory distress syndrome to chronic smokers suffering from emphysema. Current techniques for restoring ventilation create large stresses in the airway walls, resulting in tissue trauma and mortality. Improved understanding of this phenomenon may result in improved treatment methods. It is the purpose of this study to examine the effects of varying the degree of collapse on airway reopening and to compare these findings to the computational predictions of Hazel and Heil (2002) to assess the validity of the predictions.

The airway was modeled as an elastic thin-walled tube lined with a viscous Newtonian fluid. The tube was completely evacuated and refilled with a known amount of fluid to determine the initial degree of collapse. A fixed air pressure was then applied to the proximal end of the tube, inducing reopening. To prevent end effects from distorting results, fluid was allowed to drain from the distal end of the tube.

Bubble tip position and reopening pressure were recorded via video and digital sensors over a range of reopening pressures for three degrees of collapse: $A/A_0 = .117$, $A/A_0 = .176$, and $A/A_0 = .281$. The results were processed to produce correlated pairs of pressure and velocity. Observations regarding the presence and behavior of occlusions forming and dissipating upstream of the reopening region, termed secondary liquid bridges, were also recorded.

For observed values of A/A_0 the investigation revealed significant relationships in the effect of A/A_0 on yield pressure and reopening pressure on velocity, qualitatively supporting Hazel and Heil's numerical predictions. Increasing A/A_0 resulted in increased yield pressures, indicating that less pressure is required to reopen a more strongly collapsed tube. Velocity was found to increase with reopening pressure for a given degree of collapse, similar to the predicted monotonic relationship in the peeling region.

Comparison to Hazel and Heil (2002) indicated that for $A/A_0 = .281$ reopening was occurring according to pushing behavior (Gaver et al, 1996). However, increased reopening pressure in the pushing branch is predicted to decrease velocity, contradictory to experimental results. This behavior may be a result of a third branch of reopening behavior, a combination of pushing and peeling mechanics.

Qualitative relationships describing the effects of secondary liquid bridges on system behavior, cross sectional area on secondary liquid bridges, and velocity on secondary liquid bridges were interpreted from observed behavior. Theories describing the effect of secondary liquid bridges on velocity and driving pressure are proposed. Low values of A/A_0 and reopening pressure were found to favor the formation of secondary liquid bridges.

This project was conducted with support from the Department of Biomedical Engineering.

Morning Session B

Validation of the Existence of “Spore-Like” Stem Cells

Megan Kaneda

Advisors: Eric A. Nauman, Ph.D.; Kay C Dee, Ph.D. Co-advisor: Glen A. Livesay, Ph.D.

Stem cells have countless potential medical uses, but have been elusive in their classification or controversial in their origins. A possible alternative to stem cells may be found in “spore-like” cells isolated by Vacanti *et. al.*. These “spore-like” cells were isolated from various tissues in the body, found to be 5 μ m or less in diameter, and had the ability to remain dormant under conditions of oxygen deprivation and extreme temperature. Within two weeks cellular structures such as nuclei and mitochondria and tissue specific morphology were seen in “spore-like” cell cultures. The purpose of this study was to validate the existence of these “spore-like” cells from three different tissues and under two different pre-isolation conditions.

Cells were isolated from the bone marrow of 6 week old Sprawg-Dawley rats by methods described by Nauman *et. al.*, while cells from the pancreas and the spinal cord were isolated by excision of the individual organs, suspension in phosphate buffered solution, antibiotic and fungizone, and manual disassociation. Two different pre-isolation conditions were used, freshly sacrificed animal and a sacrificed animal kept at -72 degrees Celsius for fourteen days. One-third of the unfiltered suspension was plated, and the remaining suspension was passed through a 100 μ m filter. One-half of the 100 μ m filtered suspension was then plated and the remaining suspension was passed through a 5 μ m filter and plated. All cell platings remained in cell culture for 3-4 weeks.

Adherent cells and other particles were seen immediately after plating in the unfiltered, 100 μ m filtered and 5 μ m filtered suspensions of each of the three tissues. Small spherically shaped particles were most apparent in the 5 μ m filtered suspensions. All the platings stained positive for protein, intracellular esterase activity, and nucleic acids outside of a membrane but associated with the small particles. There was no statistically significant mitochondrial activity in any of the cultures.

Many possible hypotheses follow from the observed data. Although the data does not completely disprove the existence of “spore-like” cells there are discrepancies between the present study and the Vacanti’s previous study. The previous authors claimed to have tissue specific morphology at two weeks in each of the tissues studied. The present data did not produce tissue specific morphology, but instead the small spherically shaped particles were still proliferating at two weeks. Some other possible hypotheses are that we have isolated a new strand of slow growing mutant yeast, that sub-cellular structures in the filtered cells are dividing by fission in the culture, or that pieces of reverse transcriptase were present in the filtered suspension and produce strands of DNA which by some mechanism produce protein. None of the above hypotheses fully explain all of the observed data, so in reality the correct hypothesis may be a combination of two or more of the proposed hypotheses. In summary, the existence of “spore-like” cells was not completely validated using the techniques described.

This research was done at in the Cell and Tissue Engineering Laboratory at Tulane University with support from the Biomedical Engineering Department.

Verification and Characterization of “Spore-like” Cells in Rats

Jennifer Berumen

Advisors: Kay C Dee, Ph.D.; Eric A. Nauman, Ph.D.; Co-Advisor: Glen A. Livesay, Ph.D.

Stem cells are being used and have the potential to treat many diseases and conditions affecting millions of people. The existence of a new type of stem cell – a “spore-like cell” – has recently been proposed. These spore-like cells have been reported to be less than five microns in diameter (about one-fourth the size of a normal stem cell), present in all adult tissues, and able to survive harsh conditions detrimental to normal cells, including being frozen at -86°C for over two weeks and low oxygen concentrations. The purpose of this research was to replicate the experiments of these researchers to isolate, culture, and ultimately differentiate the spore-like cells into bone and neural cells.

Cells were isolated from freshly sacrificed rats and rats that had been frozen for one month. The obtained cell solutions were filtered to be put into three groups: unfiltered, 100 micron filtered, and five micron filtered (which should have contained only the spore like cells). The cultures were allowed to grow under standard conditions (5% CO_2 atmosphere and 37°C) and were monitored and given growth media (1% antibiotic/antimycotic, 10% FBS, α -MEM base) two to three times a week. Assays were performed on the cultures that tested for proteins, nucleic acids, live cell esterase activity, and mitochondrial activity.

Normal cell growth patterns were seen over time with some cultures from the freshly sacrificed tissues. In cultures from fresh tissue which had been filtered through a five-micron pore mesh and in all cultures from frozen tissue, tiny round structures (spore-like cells) were seen that significantly increased in number but did not spread out or get larger over time. Upon performance of the assays, these cultures indicated a large amount of protein and nucleic acids, little esterase activity, and no mitochondrial activity.

The results show definite evidence of the existence of structures less than five microns that will multiply under proper conditions and can survive being frozen at -73°C for at least one month. However, the results did not fully support the proposition of a new type of replicative cell because no mitochondrial activity and little esterase activity were seen. Although the possibility of a new cell is not ruled out, other explanations for the results may exist. These spore like cells could be some type of very slow growing yeast, however the cultures do not look like yeast should. Another possible explanation involves the presence of a retrovirus in all tissues that can survive harsh conditions and replicates under the proper conditions. This is supported by the lack of mitochondrial activity and the presence of proteins and nucleic acids. However, the results are not definite, and much more work needs to be done in order to determine what exactly the spore-like cells are. If the spore like cells have the capability to replicate into cells, they could potentially be used in all of the stem cell applications in cell and tissue engineering.

Funding for this study was provided by The Whitaker Foundation.

Refinement of Cornea Organ Culture to Determine Rates of Epithelial Defect Closure

Margo Snyder

Advisor: Jean T. Jacob, Ph.D. Coadvisors: Kirk Bundy, Ph.D. and Kay C Dee, Ph.D.

Methods to evaluate the corneal epithelial cell migration across wounded corneas using rabbit corneal organ culture were evaluated and refined in order to better establish a reliable, repeatable protocol.

The cornea is an avascular portion of the anterior sclera in the eye providing a transparent window through which light passes. In cooperation with the lens, the curvature of the cornea directs incoming rays to the retina where light sensitive receptors and neurons turn light into images. The inclusion of scleral tissue and limbal epithelium in the excised cornea allows this organ culture to more closely simulate *in vivo* conditions. This technique has recently been shown to be advantageous, as the rate and inward circular migration of epithelium of organ cultures corneas have closely mimicked *in vivo* wound healing.

Epithelialization across the wounded corneal surface was monitored by staining the excised cornea with fluorescein. Photographs of the stained corneas were taken at fixed focal lengths using a Nikon dissecting microscope with an attached photo control unit. The measurements of wound area were made by two independent readers projecting the resulting, scanned 35-mm slides over a metered scale in Adobe Photoshop. The rate of epithelialization was determined by the percentage of area wound closure as compared to the initial wound area.

Wound healing in the control eyes occurred from the periphery of the wound inwards. Wound closures occurred in three to four days. All images were photographed with a shutter speed of 125 and at a magnification of 0.8.

Methods to evaluate corneal epithelial cell wound closure were evaluated and refined. Revisions to existing materials and methods as previously determined by C. Vandenberg, 2002, concern shutter speed, scanning resolution, and area determination. Eventually these results could be used in evaluation of surface-modified hydrogel corneal implants.

The method refinement includes: a change in camera shutter speed from 250 to 125, assertion of a need for a fixed scanning resolution of 900 pixels/inch, and an elimination of the use of specialized software to determine the rate of epithelial migration. Further suggestions include: increasing shutter speed after day two in hopes of maintaining sufficient contrast, adhering to the initial 7.0 mm circular wound size in control eyes, and increasing the amount of technician practice to eliminate error due to inexperience.

This project was conducted at the LSU Eye Center and supported through NEI Grant #RO1.

A Design of a Device to Isolate Mesenchymal Stem Cells from Bone Marrow
Meghana Kamath

Advisor: Eric A. Nauman, Ph.D. Co-advisors: Kay C Dee, Ph.D., Francis Suh, Ph.D.

The most adaptable stem cells can proliferate and differentiate into all of the cells that humans have and need. Therefore, they have vast potential for use in injury repair and therapies for certain diseases; yet the current method of procuring these cells is complex and time-consuming. A more efficient procedure would allow researchers to obtain stem cells easily and also allow surgeons to utilize them as soon as they are available. In addition, this would minimize a donor and/or a patient's waiting period. Consequently, a design for a device that could extract and isolate these cells in the most effective and efficient manner was explored.

The first task was to determine where in the body the most stem cells could be found that could also be reached without difficulty. Next, a device was designed that could extract the cell solution, clean it by filtration, and form a single-cell suspension. Preliminary tests were conducting on soft tofu using a combination of variables associated with the design configuration. The two best configurations were chosen and subsequently tested using bone marrow from a rabbit's femur and tibia. Separately, collagen gels were made to represent the three-dimensional structure that could be formed with a single-cell solution of mesenchymal stem cells.

The two best configurations for the device were chosen from the preliminary tests based on the consistency of the final solution, the ease of handling, and how well the device endured the applied pressure. One of the configurations was eliminated during bone marrow testing due to clogging of the filters. Conversely, tests utilizing the other configuration confirmed that the bone marrow was sufficiently broken up to yield a single-cell suspension. Separately, the collagen gels formed within fifteen minutes of putting the solution into culture vessels and maintained their three-dimensional structure.

These tests proved that an efficient device to isolate stem cells after a bone marrow extraction is feasible. The combination of extraction and isolation that this device provides greatly decreases the time necessary before mesenchymal stem cells can be employed for therapies for various injuries and diseases, such as osteoarthritis, diabetes, Parkinson's disease, cancer, and muscular dystrophy. Hopefully, the patent search verifies the uniqueness of this device and warrants applying for a patent. Future research includes the study of specific differentiation pathways and seeding collagen gels with mesenchymal stem cells.

This project was conducted at Tulane University and supported through the Whitaker Foundation.

Development of an Umbilical Cord Blood – Derived Fibrin Gel For 3D Neural Grafts
Matthew A. Struck

Advisor: Eric A. Nauman, Ph.D.; Co-Advisor Robert Hariri, MD, Ph.D.

Currently, about 200,000 people are living in the United States with a spinal cord injury (SCI). Present therapies have given lower limb control and feeling back to less than 1% of patients. Stem cell grafts have been shown to regenerate some fundamental neural structures. Researchers around the world have seen 2-dimensional differentiation of adult stem cells into neural progenitor cells using several growth factors. Furthermore, Scientists at UC-Davis have used adult stem cells to regenerate ocular nerve bundles via a fibrin gel derived from the patient's own adult plasma. This graft material appears to be a possible tool in delivering a 3-dimensional stem cell graft in an attempt to regenerate transected spinal cords. The purpose of this study was to explore the possibilities of an Umbilical Cord Blood-derived fibrin gel as a means for 3-dimensional stem cell growth and neural differentiation.

Placental stem cells were first isolated using an Anthrogenesis Corp. proprietary protocol. For monolayer differentiation, human placental stem cells (hPSC's) were then seeded onto T25 culture flasks (Corning, USA) at 3.0×10^3 cells per cm^2 . 500 μM Isobutyl methylxanthine (IBMX), 1 mM Dibutyryl Cyclic AMP (dbcAMP), and 10ng/ml of Brain Derived Neurotrophic Factor (BDNF) were added to hPSC culture medium (Rea, Tulane University). Cultures were incubated for 7 days at 37°C and 5% CO₂ while changing out differentiation medium every 48 hours. For fibrin gel preparation, Umbilical Cord Blood Plasma (UCBP) was isolated from whole umbilical cord blood using a hetastarch separation and stored at 4°C until experimentation. UCBP was then recalcified and fibrin-rich serum was extracted. hPSC's were then trypsinized and added to 2D neural differentiation medium supplemented with 20% umbilical cord blood serum (UCBS). Immediately, 2 ml's of this suspension were added to T25 culture flasks (Corning, USA) and left to solidify at room temperature for 10 minutes. Cultures were then incubated at 37°C and 5% CO₂ for as long as 14 days.

2D cultures showed comparable morphology to previously documented research involving adult bone marrow stem cells. Fibrin gel formation and survival were best at 10% to 20% of total medium volume. Cell proliferation and survival within fibrin gels appeared comparable to that in monolayer cultures. 3D neural differentiation gels yielded neural cell morphologies within several cell layers. In some cases, processes were shown to proliferate through several plains within the gel. However, DNA isolates provided negative RT/PCR results for neural indicators NGF-R, Neurofilament heavy chain, and Nestin.

UCBP-derived fibrin gels appear to be a likely candidate for an animal model involving spinal cord repair. Stem cell survival and neural differentiation results were promising and provided some of the optimal criteria for spinal cord regeneration. However, some work still needs to be done on stem cell differentiation and growth geometry. Furthermore, testing on action potential conductance through this system to characterize its ability to do so, as well as neural cell maturity, is required.

This research was conducted at and funded by Anthrogenesis Corp. in Cedar Knolls, NJ.

Surgeon Hand Tremor
Scott Wheeler
Advisor: David A. Rice, Ph.D., P.E.

This research study was undertaken with the purpose of fulfilling three objectives: 1) design and develop a velocity transducer with an integrator component to provide for both velocity and displacement waveform analysis of hand tremor, 2) design and develop a simple mechanical hand tremor measuring device to allow for an uncomplicated, yet scientifically relevant means of analyzing velocity and displacement tremor components, and 3) objectively measure whether such variables as caffeine, beta-blocking drugs, upper extremity exercise, surgeon instrument grip, and anti-tremor microsurgical instruments influence surgeon hand tremor.

Surgeon hand tremor is of strong concern to many microsurgeons as inaccuracies of more than a few microns during surgery can severely affect the success of the operation, as well as the patient's recovery and long-term function. Microsurgical operations require exquisite dexterity, yet even the steadiest-handed doctor still has an imperceptible hand tremor. Hand tremor involves the involuntary shaking of the hands and is present in all people. For a surgeon performing surgery, involuntary hand motion limits the accuracy with which he or she operates. This is especially important in microsurgery where even the slightest hand tremor translates into a large movement at the tip of the surgical instrument.

Since hand tremor is regarded as deleterious during surgery, many surgeons take steps to increase their hand stability. Many surgeons refrain from ingesting caffeine prior to surgery because of the common perception that caffeine increases hand tremor. Other surgeons have tried to combat the problems associated with surgeon hand tremor by using beta-blocking drugs such as propranolol. In addition, to assist in enhancing the precision and stability of a surgeon's movements, many anti-tremor microsurgical instruments have been developed for use in microsurgical procedures. It is believed that an understanding of the factors influencing hand tremor may allow a surgeon to take steps to prevent increased tremor.

There is no universally accepted definition for tremor; however, tremor is most commonly defined as the involuntary, rhythmic oscillation of reciprocally innervated, antagonistic muscle groups, causing movement of a body part about a fixed plane in space. Tremor can affect various body parts such as the head, facial structures (chin, tongue, lips and ears), vocal cords, trunk, and legs, however, ninety-four percent of all tremor occurs in the hands and may be unilateral or bilateral.

It is possible to measure tremor and assess its impact on patients in a variety of ways. These include electrophysiologic techniques (e.g., electromyography (EMG), accelerometers, velocity and displacement transducers, spectral analysis, and weighting of the body part), clinical rating scales (e.g., tremor scale), and simple objective tests of hand and arm functions. For the purpose of this research study, a velocity transducer with an integrator component was designed and developed to provide for both velocity and displacement waveform analysis of hand tremor. In addition to this model, a simple mechanical hand tremor measuring device was designed and developed to allow for an uncomplicated, yet scientifically relevant means of analyzing velocity and displacement tremor components.

This project was conducted with support from the Department of Biomedical Engineering.

The Use of Personal Digital Assistants to Increase the Medication Compliance in the Elderly
Justin Guay

Advisor: David Rice, Ph.D. Readers: Ron Anderson, Ph.D. and Cedric Walker, Ph.D.

Memory allows the understanding and knowledge necessary to live an independent life. Memory failure often occurs in elderly populations, and decreases their ability to function independently. Due to increasing amounts of medication that a person consumes as age increases, memory failure results in decreased medication compliance. This causes declining health, unnecessary doctor visits, early entry into assisted living situations, and premature death. If reminding technology could be used to increase compliance, the elderly could live a happier, healthier, and longer life. However, this technology may be difficult for the elderly to use because many elderly persons are not comfortable using complex electronic devices. The purpose of this project was to develop a program on a PDA that alerts the user to take medication and to assess its effectiveness among users of differing levels of familiarity toward electronic devices.

A program was written for the Palm V to test the capabilities of reminding technology. This program was administered to 6 subjects of varying degrees of familiarity with Palm Pilot to test if the effectiveness of the program differed based on the user's level of familiarity. Each subject was given a list of medications to take at certain times over the period of four days; two days using the program and two days using a paper and pencil method. Each subject was also interviewed before and after the testing period in order to assess the subject's familiarity with electronic devices and to receive feedback on the design of the program. This information would be used to test two hypotheses: (1) a subject's familiarity with PDA's positively correlates to his PDA performance, and (2) a subject's familiarity with technology positively correlates to his PDA performance.

Data from this study showed that the PDA method was more effective than the paper pencil method in getting the subject to take the medication at the correct time. However, it could not determine the PDA method's overall increase in medication compliance because programming errors caused the PDA to function abnormally in several cases. Data from the questionnaires was compiled and it was found that those who rated themselves low in PDA familiarity greatly on the pre-questionnaire increased their PDA familiarity rating by an average of 3.5 points out of 10.

When the results from this experiment were interpreted, support was found against the hypothesis that a person's familiarity with PDA's is not a factor in the usefulness of the technology. Additionally, no support for a correlation between a person's familiarity with technology in general and a person's successfulness at the PDA method was found. However, more data from people of low technological familiarity must be gathered in order to make any decision about the hypothesis.

Support for this project came from the Biomedical Engineering Department of Tulane University.

Design and Implementation of a Wireless Data Acquisition System
Jorge Nagel
Co-Advisors: Cedric Walker, Ph.D.; Donald P. Gaver III, Ph.D.

Research projects commonly involve the collection and manipulation of data from experiments. This is usually done through personal computer (PC)-based data acquisition and control systems. A transducer, a device that converts a physical quantity into an electrical signal, is used in the first step of the data acquisition process. The signal is then conditioned (amplified, attenuated and/or noise filtered) in preparation to be input into the computer. The signals produced by the transducer can be digitized into computer memory through plug-in expansion boards that contain analog-to-digital converters or stand-alone interfaces that transfer data to the computer through a serial port. A software package such as LabView is then used to analyze and save the data.

PC-based systems are widely used in laboratory applications such as monitoring, control, data acquisition and automated testing. These systems are usually set up in labs where the experiments take place. Sometimes, however, the characteristics of an experiment do not permit its realization inside a lab. In such cases, a portable system is desired. Portability also allows for in-class presentation of projects and demonstrations of lab experiments. The purpose of this project was to design a system containing all the equipment necessary to monitor, record and control an experiment while still maintaining portability.

A portable data acquisition system, with wireless Local Area Network (LAN) connection, was designed and implemented using off-the-shelf and custom-made components. Engineering Faculty was consulted regarding their individual needs in data acquisition. Components were selected in accordance to the Department's needs while taking into account the most cost-effective solutions.

Furthermore, a Virtual Instrument (VI) written in LabView was created to accommodate the most common situations in data acquisition. The program uses the information provided by the user (such as sample rate, number of data points, etc.) to acquire and process data from the selected channels. The program also provides for instrument calibration and save-to-file functionality among other things. Proper measures were taken to make the system as intuitive as possible and to prevent system crashes due to erroneous settings provided by the user.

The system was tested with different users including Biomedical Engineering students and faculty members. The reliability and flexibility of the system have been verified in different environments and circumstances obtaining satisfactory results.

Support for this project was provided by the Biomedical Engineering Department and the National Science Foundation.

Engineering Management: A Proposal for Tulane University
Odelya Levy
Advisor: Nicholas J. Altiero, Ph.D.

Engineering management is a program that would combine courses in the A.B. Freeman School of Business and the School of Engineering to give students an education based on the technical core of engineering, mixed with the knowledge and skills of management, to better prepare them for their future careers in today's workplace. According to recent studies, 50% of the students who drop out of the School of Engineering enroll in the A.B. Freeman School of Business. The purpose of this project is to design an engineering management major for Tulane University to determine if the retention rates in the School of Engineering would increase if the students had this option, and to find out if there is an existing demand for this program at Tulane.

The curriculum is designed to fulfill the Accreditation Board for Engineering and Technology (ABET) EC 2000 criteria. Once the curriculum was developed, a survey was distributed to the freshmen and senior engineers, the upperclassmen in the A.B. Freeman School of Business, and former engineering students who initially enrolled in the School of Engineering during the 1999-2000 academic year. In order to determine which students dropped out of the School of Engineering, the incoming class of 1999 was traced from their freshmen year through their senior year to deduce which of those students made it throughout their four years, and who transferred out.

The surveys showed that 81% of the 135 freshmen engineers surveyed would or might have considered engineering management if it were offered. Of the 123 senior engineers surveyed, 72% replied that they would or might have considered engineering management an option. Of the 52 upperclassmen business students surveyed, 33% answered that they would or might have considered taking this major. Of the 9 former engineering students who responded, 56% said they would or might have considered engineering management if it had been offered.

The results of the survey proved that if engineering management were offered at Tulane University, there would be a significantly large demand for it. The students most inclined to pursue this degree would be the freshmen engineers, which is the most essential target group from the retention standpoint. The response was not as positive in the business school with the majority replying that they would absolutely not consider such an option. However, the surveys showed that there still is a small demand for engineering management in the business school which would be beneficial for the School of Engineering because not only could they retain more of their students, but providing this major would also attract students to the School of Engineering who never considered engineering an option in the past. It is concluded that creating an engineering management major would be worthwhile for the School of Engineering at Tulane University.

This project was conducted through the Dean's Office in the School of Engineering at Tulane University.

Afternoon Session A

Creation of a Tissue-Engineered Soft Tissue-Hard Tissue Interface Through Cytokine Diffusion

Darryl Athos Dickerson

Advisors: Glen A. Livesay, Ph.D., Kay C Dee, Ph.D.; Co-Advisor: Eric A. Nauman, Ph.D.

It is estimated that 200,000 (ACL) injuries occur in the United States every year. Because ligaments play a major role in normal joint movement and knee joint stability, untreated ACL injuries can lead to other injuries that further compromise motion at the joint. Currently, surgical reconstruction is the most prescribed option for active patients; approximately 60,000-75,000 ACL reconstructions are performed in the United States annually. No current reconstruction technique reproduces the normal insertion, the histologic transition zone between the ligament and bone. The objective of this study was to utilize diffusion of bone morphogenetic protein-2 (BMP-2) to produce directed phenotypic modification of precursor cells to create a soft tissue-hard tissue interface comparable to what is found *in vivo*.

A numerical model of BMP-2 diffusion was programmed in Matlab based on Fick's law. Final results from the program were used to determine the effective diffusing distance of BMP-2 within a three dimensional matrix. To determine the efficacy of BMP-2 diffusion in creating a gradient of differentiation, adult rat bone marrow stromal cells were cultured either under or within a collagen gel in a 12 well tissue culture plate. The center of the gel was punctured to form a vertical channel. The channel was filled with 10 μ L of BMP-2 at 10 ng/mL or 100 ng/mL. The gel was then covered with 1 mL of DMEM supplemented with 10% FBS. After 24 hours, the media was aspirated and the same pulsing procedure was done. Live/Dead cytotoxicity assay, histochemical alkaline phosphatase (ALP) assay, and Alizarin red staining were performed on the samples.

The first experimental run of cells embedded within the collagen gel produced large collagen gel contraction. When retrieved from culture after two weeks, the gels were less than a third diameter of the culture well. Histochemical ALP tests run on these samples showed a gradient of increasing ALP activity from the center of the gel radially outward. In order to combat gel contraction, small collagen fibers were used for collagen gels embedded with cells. These gels were removed from tissue culture at day 10 due to a compromise in sterility in five of the sample wells caused by gross incubator contamination. One collagen gel each from the control and 10-ng/mL groups was infected as well as all of the 100-ng/mL gels. The cytotoxicity assay showed a good amount of living activity within all samples; however, the cells were not morphologically the same in all of the samples. The histochemical ALP assay showed only marginal ALP production on the outer edges of the uninfected gels. Infected gels showed no ALP activity. It is uncertain whether this pattern of staining was a result of diffusion limitation due to gel size. Thus, the experiment could neither confirm nor deny the utility of BMP-2 diffusion in engineering an insertion. While the experimental approach used for this study is sound, future studies should employ an actual physical separation of chemical environment. In this way, the chemical environment can be more heavily weighted to produce the desired phenotypic differentiation of the precursor cells.

This project was conducted in the Biomechanics Lab and Cell and Tissue Engineering Lab within the Department of Biomedical Engineering at Tulane University. This project was supported through NSF Career 0093969.

Three-Dimensional Characterization of a Normal Soft Tissue to Hard Tissue Entheses
Alycia Wanat

Advisors: Kay C Dee, Ph.D., Glen Livesay, Ph.D.; Co-advisor: Eric Nauman, Ph.D.

Each year six million people seek medical treatment for a knee injury. A substantial number of those people will tear a ligament in their knee and require surgical intervention. A possible solution to this problem could be the application of tissue engineering in order to design a ligament that has biomechanical properties similar to that of the body's ligaments and that has a legitimate soft tissue-bone interface (insertion). A tissue-engineered ligament would provide adequate mechanical strength as well as a suitable replacement for the original ligament. In order to complete a successful insertion of the ligament into the bone, the three-dimensional characteristics of a normal insertion must be described. The three-dimensional characteristics include the chemical and cellular composition of the insertion and the topography of the bone underneath the soft-tissue as it inserts into the bone. Observing these characteristics will provide understanding of the structure in addition to design criteria to re-create this structure in the lab. The purpose of this project was to characterize the three-dimensional characteristics of a hard tissue to soft tissue enthesis.

Porcine lateral collateral ligaments (LCL) and anterior cruciate ligaments (ACL) were obtained, and excess tissue was removed from the entheses. The tissue was decalcified using Jenkin Fluid (ethyl alcohol, distilled water, chloroform, acetic acid, and hydrochloric acid) for one day, and then dehydrated by placing it in consecutive ethyl alcohol baths. The tissue was embedded with Technovit, then it was sectioned into 5-micron slices and stained with Modified Mallory's Stain. Using a Roland PICZA Model PIX-4 3-D contact scanner, surface topography was also measured.

Images collected after sectioning the insertion clearly showed the four different zones of a direct enthesis: ligament, fibrocartilage, calcified fibrocartilage, and bone. The number of cells changed from few in number near the ligament to numerous, round cells near the fibrocartilage. The four zones and cell characteristics confirmed what has been published in the literature. Topography measurement of the insertion site was not as successful. The intent was to find evidence of interdigitations (small pieces of ligament inserting into the bone structure) of the ligament into the bone. After the bath, the bone was soft and gelatin-like; therefore, it seems the collagenase bath partially dissolved the bone.

If a tissue-engineered ligament had a soft tissue-bone interface, the success rate of reconstructive surgery would increase and therefore need for repeated surgery due to implant failure would decrease. By characterizing the three-dimensional characteristics of a natural soft tissue to hard tissue enthesis, it will be possible to construct a tissue-engineered enthesis which more accurately resembles a natural one, and this would reduce the need for repeated surgery due to implant failure.

This project was conducted at the Biomechanics Lab and Cell and Tissue Engineering Lab within the Department of Biomedical Engineering at Tulane University and supported through NSF Career #0093969.

Multi-Axial Functional Evaluation of the Normal Anterior Cruciate Ligament and Replacement Graft

Kevin Wasco

Advisor: Glen Livesay, Ph.D.

The Anterior Cruciate Ligament (ACL) serves an important role in guiding motion in the knee joint, and in this capacity it is often injured. Surgical reconstruction is advocated for active patients to restore a measure of stability, and is commonly performed by replacing the damaged ACL with a biologic graft bridging the joint space between the tibia and femur. Currently, the most common ligament replacement is a segment of the patient's own patellar tendon secured in place with an "interference fit" screw.

There have been many previous studies that have used the standard pull-out test to evaluate the mechanical function of the ACL replacements "interference fit" fixation. These tests have allowed for the determination of the stiffness and strength of a reconstructive fixation and comparison to the normal ACL. However, this testing may not fully capture the actual function of these fixations since the pull-out tests determine the response of the fixation at a single orientation although they must function in multiple directions in the reconstructed knee. We propose that to fully characterize the function of the fixation, testing has to be done to determine the response of graft fixations at different orientations.

For this test, six porcine ACL bone-ligament-bone complexes were evaluated using a custom-built multi-axial testing device. A series of load-elongation tests were then performed at different combinations of rotations about the y-axis and the x-axis. Six porcine Patellar tendons were then secured in a polyurethane bone tunnel with an interference screw using a technique imitating actual ACL reconstruction. These analogs were then evaluated in similar fashion to the ACLs.

Results suggested that the interference fixation changes the stability and function of the graft insertion and does not mimic normal ACL function. These changes may be due to differences in length between the normal ACL and the patellar tendon graft, movement of the graft after reconstruction is performed, and, also, differences in the geometry and morphology between the insertion points of the ACL and the fixation developed between the interference screw and the tendon graft.

This work was conducted at the Biomechanics Laboratory of the Biomedical Engineering Department at Tulane University.

Acoustic Characteristics And Mechanical Properties Of Articular Cartilage And Its
Major Molecular Components
Aston Oldendorf

Abstract unavailable at the time of publication.

A Device to Evaluate the Mechanical Properties of Biological Tissues in Tension
Amber Williams

Advisor: J-K Francis Suh, Ph.D.; Co-advisors: Ronald Anderson, Ph.D., Donald Gaver, Ph.D.

Almost 5.3 million people in the United States today are living with irreversible disabilities resulting from traumatic brain injuries (TBI). Many investigators have used biomechanics to understand the damage caused to the brain, but the complex anatomy and physiology involved in head injuries has significantly complicated this endeavor. The goal of brain biomechanics is to relate the mechanical aspects of an injurious event to the severity of the wound, specifically regarding changes in structure and function of the brain. Local tissue testing is necessary to establish the mechanical properties of specific structures, and this data may be incorporated into a mathematical model of head injury. The overwhelming majority of the mechanical testing on brain tissue is under compressive stresses, mainly due to the difficulty in fixing the tissue to a tension testing machine. While it is understood that positive and negative pressures occur at opposite sides of the brain during injury, the published data can only describe the tissue response under the positive pressure. The purpose of this study is to develop a device to assess the tensile properties of biological tissues for specific application in brain biomechanics.

A design based on the pipette aspiration method was created; the system consists of a 60ml syringe, a laser displacement sensor, a vacuum-sealed chamber, and plastic tubing. A small inflexible plastic tube extends from the chamber and is positioned to suspend above the sample in direct contact with the tissue surface. The extension of the syringe creates a sub-atmospheric pressure in the chamber, which causes the tissue to deform upward into the small tube. The laser displacement sensor measures the distance to the surface of the sample before and after the deformation, allowing for the assessment of the pressure/displacement relationship in the sample. In order to validate the effectiveness of this testing system, brain tissue samples were substituted with tofu of varying elasticity, allowing the system to be refined without wasting valuable animal tissue. Three types of tofu were utilized, soft, firm, and extra firm, and the samples were tested in ten different locations on the surface of each material. Each test consisted of a full withdrawal of the syringe, generating negative pressures up to 80 kPa. The displacement of the material was recorded for every 10 kPa decline in pressure, for a total of eight data points per test.

By combining the data from the measured pressure within the chamber and the resulting deformation, pressure/displacement curves were produced. The tensile testing system was able to demonstrate the differences in elasticity between the three samples. The extra firm samples showed much less deformation under pressure than the other two types, and the soft tofu showed more deformation than the firm tofu.

The next step in this line of research is obviously to use the apparatus to test brain tissue samples. As the tensile behavior of the tissue is more clearly understood, the subsequent brain injury models will approximate actual injury with more consistency. Finite element analysis and other mathematical modeling tools hold the future for brain biomechanics because they are equipped to account for the complex geometric and mechanical properties of structures in the head as well as the various parameters of the impact. Eventually, these models will bring us closer to understanding the countless mechanisms involved in brain injury.

This project was conducted with support from the Department of Biomedical Engineering.

Automated Analysis of Macular Degeneration
Curtis Michael Humphrey
Advisor: Cedric F. Walker, Ph.D., P.E.

Macular Degeneration is the leading cause of irreversible vision loss in the United States. This incurable condition affects a portion of the retina, a thin multi-layered membrane which lines the inside back two-thirds of the eye. Macular degeneration progressively damages or destroys the part of vision used for reading and seeing fine details, while leaving the peripheral vision generally unaffected. It has been discovered that patients with macular degeneration have considerable problems with recovery of vision from bright lights. Bright lights cause the saturation of the vision cells. When the bright lights are removed there is a recovery period during which the eye becomes unsaturated, thereby restoring vision in low-light settings. The measurement of this delay time is the basis for testing changing conditions in patients with macular degeneration. The purpose of this design project was to design, develop, and prototype a working device for detecting and measuring changing conditions in a patient with macular degeneration based on the measurement of the recovery time.

Founded on this concept of recovery time the following basic testing procedure was developed. The patient places his eye at the entrance of a tube that houses both the flash source and a numerical display. The patient's eye is simultaneously flashed, causing snow-blinding, a random number is displayed on the numerical display, and the timer started. When the numbers are readable the patient pushes a button thereby stopping the timer. If the number entered by the patient matches the displayed number then delay time is recorded; otherwise, the patient must repeat the test. After recording the delay time, analysis is performed and the patient is told to see his doctor if his macular degeneration has significantly gotten worse; otherwise, he is asked if he wants to test his other eye. If he does, the whole test is repeated for the other eye.

This testing procedure was implemented as an in-home self-tester with memory of one patient's previous delay times. The manifestation of this testing procedure was an electronic device centered around a microcontroller that coordinates the sequential testing steps, processes user input entered on a keypad for verifying correctly read numbers, displays instructions and feedback on a LCD panel, acts as a stop watch, records delay times into long term memory, and performs the analysis and gives warning if a doctor needs to be contacted.

The prototype performed the testing procedure accurately. The Basic Stamp IIe was the microcontroller of choice, and the user program for operating the testing procedure was robust. The delay time was measured to a tenth of a second and the timing lag was under a tenth of a second for every 60 seconds. The greatest unresolved issue was that of aligning the affected region of the retina due to the snow-blinding from the flash with the region that is used to view the display numbers – if the snow-blinding occurs in the peripheral vision the eye has little problem seeing the display numbers and there is no abnormal delay time. The future design work that will be explored as part of the Master's version of this thesis is as follows: solving the co-linearity requirement, developing a statistical database based on field testing, fine tuning the analysis of when the patient's macular degeneration has digressed, and construction of a manufactured version.

This project was conducted with support from the Department of Biomedical Engineering.

Studies of Enzyme Inhibition Biosensors
for Applications in Natural Environments and *In Vivo* Richard D. Collier III
Advisor: Kirk J. Bundy, Ph.D.; Advisor: Jean T. Jacob, Ph.D.; Reader: Kay C Dee, Ph.D.

In this study, biosensor concepts using biomolecular recognition principles were explored, potential applications for such devices in the environmental, biomedical, and antiterrorism fields were identified, and critical factors for development of affinity and catalytic biosensors based on these concepts were addressed. Such biosensors are capable, in principle, of detecting small concentrations of agents of interest even when faced with substantial interferences from extraneous molecules.

When biological sensing elements (enzymes, receptors, and antibodies, for example) are coupled to a transducer, they yield a signal proportional to the concentration of their specific target molecules (substrates, ligands, antigens). While this approach may provide a distinct advantage over conventional sensors, it is not without its shortcomings. Major barriers to overcome include loss of functionality due to protein denaturation, difficulty in operating in dry/low-humidity environments, and difficulty in sensing airborne contaminants. Some of these problems may, in principle, be obviated by using hydrophilic polymer hydrogels as the carrier for the sensing elements.

This investigation was composed of two parallel studies. First, nerve agent-surrogates malathion (MA) and pirimiphos-methyl (PM) were detected based on their inhibition of the enzyme butyrylcholinesterase (BuChE). Second, numerous metal ions of biomedical interest were detected based on inhibition of urease (Ur). The enzyme-based biosensors were constructed by immobilizing the enzymes either on polyamide nylon membranes or in hydrogel polymers. A pH meter monitored reaction product concentrations. Throughout testing, efforts were made to optimize our assays by identifying controllable parameters that could enhance assay sensitivity.

Tests with BuChE sensors yielded detection limits in the part-per-million range for MA and PM. Tests with Ur sensors yielded detection limits in the part-per-billion to part-per-million range for several metallic ions including Ag^+ , Hg^{+2} , and Cu^{+2} . As a result of our assay optimization studies, we were able to produce maximal sensor responses, lower detection limits, and more reliable, repeatable detection data.

The BuChE sensor may have promise both for environmental pollution analysis and military defense/antiterrorism efforts. After optimization, an Ur-based hydrogel biosensor could possibly be used to assay saliva and other body fluids *in vivo* to detect metal ion dissolution due to corrosion of dental restorations or surgical implants. Overall, we have proven that biosensors with these enzymes immobilized on polyamide membranes will serve as effective benchmarks for further hydrogel-based biosensor investigations. The findings of our optimization studies should all be transferable to hydrogel-based sensors, and ultimately could greatly improve the efficacy of this technology.

This project was conducted at the Department of Biomedical Engineering, Tulane University and the LSU Eye Center. Funding from NSF-EPSCoR contract (2001-04)-RII-02 and NASA grants NAG-1-02070 and NCC3-946 (TIMES) is gratefully acknowledged.

A Comparative Study of Devices to Detect Herpes Simplex Virus by
Quantitative Real-Time Polymerase Chain Reaction

Erin Corinne Riley

Advisor: James Hill, Ph.D.: Coadvisors: K.C. Dee, Ph.D., Partha Bhattacharjee, Ph.D.

Since the development of the polymerase chain reaction (PCR), many advances in gene discovery and analysis, diagnostic virology, and pathology have been made. However, since conventional PCR has many limitations in quantitative analysis, with end point detection of amplified product rather than detection in real-time and has been rendered cumbersome and timely by many researchers, recently, rapid cycle, high throughput, real-time PCR was introduced. Real-time PCR has proven to have many advantages over conventional PCR for it is extremely sensitive, accurate, aseptic with all reactions taking place in tightly sealed reaction modules with no post-reaction handling. Real-time PCR also provides not only qualitative but quantitative analysis of genes at each amplification cycle of PCR. Real-time PCR is based on the detection and quantification of a fluorescent reporter that is based on Fluorescence Resonance Energy Transfer (FRET). Thus, reliability of data heavily relies upon both the type of reporter and type of probe chosen, such as the Taqman assay, the software included and the mechanical technology of the thermocycler.

In this study, three real-time PCR devices (Applied Biosystems Prism 7700®, Biorad Icyler iQ™, and Cepheid Smart Cycler®) were compared, encompassing the overall design, cost, ease of use, assay run time and desired results. The assay used for comparison of accuracy of detection was made up of a dilution series of 24-million copies/ul plasmid carrying polymerase gene of Herpes Simplex Virus type 1(HSV-1). The assays contained a total of 22 samples made up of duplicates of each dilution, with each sample containing 2.4×10^6 copies/ul to .0375 copies per/ul to and two negative controls (containing only master mix without DNA) to compare the sensitivity of detection.

Standard curves of the log of the quantity of DNA in each sample compared to the threshold cycle value (Ct) generated by the instruments were plotted. The most accurate device according to the best R^2 value was the Bio-Rad Icyler ($R^2 = .992$). The device that was the most sensitive, detecting 60 copies of HSV-1 plasmid DNA was the Smart Cycler. The ABI 7700 run resulted in no amplification because primer/probe concentrations were too high. These results combined with the Icyler's large sample capacity and ease of use determined that the Icyler was best suited for a virology lab where as many as 6,000 samples needed to be analyzed for the presence of HSV-1.

Aspects such as pipetting errors, primer/probe specifications by the manufacturers and varying protocols for each of the real-time PCR devices could have significantly influenced on this study. However, ease of use and accuracy to the typical virology lab employee was a main goal of this research and shows that the Icyler was the most appropriate device for the laboratory.

This study was conducted at the LSU Eye Center and supported through US Public Health Service Grant EY06311 (JMH), NIH Grant # EY02377, a Research to Prevent Blindness Senior Scientific Award (JMH), an unrestricted departmental grant from the Research to Prevent Blindness, Inc., New York.

The Extraction of McKrae-EGFP HSV-1 Cells via Laser Microdissection

Michael J. Ryan

Advisor: James M. Hill, Ph.D.

Enhanced green fluorescent protein (EGFP), when inserted into the genetic sequence of herpes simplex virus type 1 (HSV-1), causes neuronal cells to fluoresce green when infected. Laser capture microdissection (LCM) and laser pressure catapulting (LPC) were both developed so that specific cells could be efficiently collected from a heterogeneous cell population. Fluorescent attachments were developed for each instrument so that cells exhibiting natural or lab-induced fluorescence may be targeted and collected with ease. For genomic analysis, collection of these infected fluorescent cells by LCM and LPC was followed by RNA extraction and PCR. This study investigated the ability of LCM and LPC to provide cells exhibiting EGFP fluorescence with intact RNA and DNA.

Rabbits and mice were infected with the McKrae-EGFP strain of HSV-1. On post-infection day 28, the test subjects were sacrificed. Trigeminal ganglia were removed from each animal and examined in culture for signs of fluorescence. Those that exhibited EGFP were sectioned and subjected to microdissection, followed by PCR. Both RNA and DNA were tested against appropriate controls on an agarose gel. LCM was performed with an Arcturus PixCell Ii. LPC was performed with a PALM Microlaser. Both instruments were compared using a set of criteria including results, instrument design, software design, ease of use, and cost.

EGFP expressing cells were found in the trigeminal ganglia of both rabbits and mice, though exhibition in mice was more readily noticed. The cells that exhibited fluorescence were easily collected by both LCM and LPC, with few minor problems involved in each technique. Quantitation of RNA with the help of LCM proved that amplification techniques assured enough RNA for efficient genomic analysis. Both microdissection methods were therefore successful.

LCM and LPC both proved effective in removing cells tagged with EGFP. Difficulties were encountered in microdissection of tissue samples that had not been dehydrated, regardless of the instrument being used. Minor setbacks were come across concerning the software utilized by the PALM Microlaser. Overall analysis shows the Arcturus PixCell Ii to be the better instrument for dissection of specific cells from a heterogeneous tissue sample, even though the technique of LPC is preferred. LPC obviates mechanical contact with the sample, but PALM's instrument costs substantially more than Arcturus', and although its software offers more automation, it also contains more glitches, making the system more difficult to use. Possible future directions for microdissection include improved automation and additional features in genomic analysis.

This project was conducted at the LSU Health and Science Center through NIH Grant # EY09171.

Verification of Assumptions Used in Determining Corneal Cell Adhesion to
Hydrogels With a Jet Impingement Method

Albert Stolz

Advisor: Jean Jacob, Ph.D. Advisor: Kirk J. Bundy, Ph.D.

Artificial materials to aid in the repair of corneal defects have been under development for many years; although significant progress has been made, the optimal material has yet to be achieved. The ultimate goal is to develop a material that will allow corneal epithelial cells to attach and form a normal epithelial structure. Earlier experiments have investigated the ability of rabbit corneal epithelial cells to adhere to synthetic hydrogel material. The ability of cells grown on laminin-treated hydrogel material to adhere even in the presence of 52.6 Pa of shear stress was documented. Before this data can be accepted certain concerns resulting from the methods used in that experiment must be investigated. In this study, the possibility of deformation of the hydrogel during impingement was investigated.

Deformation of the hydrogel was visually measured in a specially designed flow chamber and documented with digital photography. No significant surface deformation could be observed during impingement under standard flow conditions. Blunt object indentation of the hydrogel proved significant visual distortion occurred which would hide small surface deformation. Indentation could be observed only past depths of 0.2mm when the blunt object was 1mm from the front of the chamber. Deformation due to impingement pressures could therefore not be measured accurately, but is less than 0.2mm.

Though experimentally significant deformation in the 0.1mm range could not be disproved, numerical strain calculations and qualitative analysis of the flow conditions strongly support no deformation. All visually observed qualities of the flow during impingement match well with the theoretical behavior of a laminar jet. Since effects of significant deformation would be visible the assumption of rigidity of the hydrogel seems justified.

This project was conducted at the LSU Eye Center.

Afternoon Session B

Mechanical Testing of Athletic Shoe Cushioning Systems for Optimized Performance
Luke Hooper

Co-Advisors: Glen A. Livesay, Ph.D., Eric A. Nauman, Ph.D., Donald P. Gaver, Ph.D.

Research has shown that shoe design can have a significant effect on athletic performance in terms of improved oxygen consumption through more efficient biomechanics. However, predicting the response of an individual to a specific shoe design is a difficult problem due to the extremely varied and adaptive nature of human gait. Increasingly, complex shoe designs are being created that can yield non-linear, viscoelastic location dependant responses. Despite these significant changes in shoe design, very little work has been done into improvement or expansion of the original athletic shoe mechanical tests introduced over the past three decades. Improved mechanical testing offers the possibility of predicting biomechanical response and even perceived levels of comfort through characterization of the shoe cushioning system over a range of responses.

As a first step, the current impact testing method was modified and expanded. Impact testing, consists of dropping a weight from a set height onto the shoe impacting its surface with a rigid 'tup' of a specified geometry. This is currently conducted at one condition measuring the impact head's deceleration allowing for calculation of the maximum deceleration (Peak G), energy loss, and deformation. The effect of varying the mass and height of the test while maintaining the current level of energy input was first observed. After characterizing the constant energy response, impacts at five different velocities and five different masses with varying level of energy input were conducted on three shoes. The heights and masses were chosen in relation to the current set value in an effort to correspond to different user weights and running speeds.

Peak G (the maximum deceleration of the impact head in gravitational units) responses of the shoe were analyzed in terms of the input conditions for each study. The constant energy study showed Peak G to be inversely correlated to the impact mass and linearly correlated to the average deformation rate. The varied energy study yielded inflection points and extremely varied localized responses for Peak G vs. impact mass and velocity for the different shoes tested. Three dimensional plotting of these results points towards an optimized range of response for each shoe characterized in terms of heel deceleration at certain inputs.

The study showed promising results for predicting an optimized range of responses in terms of a user mass and running speed. 3-D characterization of other measured variables such as energy return coupled with biomechanical correlations to the impact conditions tested could lead to direct application of impact testing as a key predictor of actual shoe performance over a wide range of users.

This study was conducted and supported through Nike Inc.

An Investigation of Forced Use and TENS Treatments for Childhood Hemiparesis

Susan Zawaski

Advisor: John Willis, MD; Reader: Sherry Werner, Ph.D.; Reader: Cedric Walker, Ph.D.

Hemiparetic cerebral palsy is a condition in which the patient has weakness and poor motor control on one side of the body due to brain injury in early life. Its pathology is static, although motor function patterns may change over time. One result of hemiparesis is an abnormal gait pattern. Hemiparesis contains a variety of homogeneous patterns of gait, which often include abnormal hip and knee flexion, slow walking speed, increased step width, and abnormal ankle rotation. This study investigated the effects of forced use and Transcutaneous Electrical Nerve Stimulation (TENS) on the gait of patients with hemiparesis.

Four patients between nine and twenty-one years of age with hemiparesis due to brain injury were treated. Two patients received a plaster cast on their unaffected foot and ankle that was left in place for thirty days (forced use). One patient was provided stimulation to the weak foot and ankle through electrodes that were connected to a TENS unit. This patient wore the device an average of 5.6 hours per day, for twenty-four days out of the thirty days of treatment. Another patient acted as a control and received neither casting nor TENS. Objective assessments of gait for each subject were performed before and after the treatment period. A total of twenty-three gait parameters were evaluated for each patient. During the study, no efforts were made to change the patients' routines. The subjects continued any routine visits to physical therapy.

The criterion for a significant normalization in any gait parameter was a fifteen percent change in value either toward or away from the normal mean value of that parameter. After treatment, both patients that received forced use therapy showed significant improvements in their gait assessments. The gait of the patient that received TENS therapy also normalized significantly. The gait of the patient that acted as a control and received neither casting nor TENS normalized significantly, but this patient was recovering from hip surgery and undergoing physical therapy so gait improvement was to be expected.

This study provided preliminary evidence that forced use and TENS therapies can be effective rehabilitation techniques for patients with hemiparesis. Further studies need to be carried out in order to determine the degree to which forced use and TENS treatments improve gait. A larger control group also needs to be studied to provide a stronger basis for comparing the degree of improvement between patients. Plasticity and cortical reorganization may explain the improved motor function observed through the use of these therapies. Further investigations need to be done to better understand the mechanisms behind the observed motor improvements.

This project was conducted at the Tulane Institute of Sports Medicine.

Design Of A Forced-Use Treatment Restraint For Children With Hemiparesis

Lorey Flick

Advisor: John Willis, M.D.

Hemiparesis is defined as a weakness on one side of the body that impairs mobility and extensor movements. Rehabilitation for this disorder is difficult in adults, but children suffering from hemiparesis are more likely to make substantial improvements, presumably because their motor skills and brain function are more plastic. A recent study has shown the effectiveness of using a forced-use treatment method on children suffering from hemiparesis, but the current method of treatment is highly uncomfortable and is known to be inconvenient for both the parents and children. A plaster cast was originally used and placed on the healthy forearm of the patient for one month, resulting in increased function of the hemiparetic arm. The positive results of this study prompted researchers to seek a restraint that would be tolerable by the young patient. The purpose of this project was to design a patient-friendly forced-use treatment restraint that incorporated a locking mechanism and toy attachment to prompt fine digital movement and distal extension of the hemiparetic arm.

The steps taken to complete this project included gathering information on current restraint treatments used in the medical field, both for adults and children. The properties and uses of the materials necessary for the restraint were identified, including the material used for the restraint, the internal lining, the locking mechanism, and the variety of toy attachments. The restraint's shape, size, and locking mechanism were custom designed to provide a secure fit and tolerated by the patient. A prototype was made using conventional fabrication methods and tested for comfort and durability.

The final design chosen for this project included a bi-valve system made of 3/16" polyethylene plastic. It was held in position by six plastic six-lobe tamper resistant machine screws, with a tapped 8-32 thread and 3/8" round spacer. The restraint covered the forearm from the tips of the fingers to the base of elbow, with three counter-sunk holes on each side to house the locking mechanism. The appropriate toy attachments were held into place on the restraint using a permanent Velcro adhesive located on the upper valve of the system.

This design was optimal for the young patient in mind, in that it can withstand water submersion and was stronger than the previous restraint used. In addition, the locking mechanism was made of a non-corrosive, hypoallergenic nylon plastic material that has high heat resistance and toughness. The new restraint was favored over the traditional plaster cast because it gave the patient more freedom than the plaster cast. Future goals for this design include acquiring a patent and providing patients with this treatment design by implementing mass-production of the restraints for treatment of children between the ages of one and eight.

This restraint was made at Bayou Orthotic and Prosthetic Center and supported through Dr. John Willis in Pediatric Neurology at Tulane University Hospital.

A Device and Method of Gait Analysis for Diabetic Neuropathy
Michael Palazzolo
Co-Advisors: Glen A. Livesay, Ph.D., Eric A. Nauman, Ph.D.,
Cedric Walker, Ph.D.

The peripheral nerves degenerate in diabetics due to irregularity in glucose diffusion. This problem is primarily manifested in the foot, leading to complications such as soft-tissue contractures and amputation. Treatments for the neuropathic foot include orthotics, casts, and tendon-lengthening surgery. These classifications are all preventive; they attempt to alleviate force and correct an aspect of the abnormal mechanical environment associated with diabetic neuropathy. The method presented in this study could be used to estimate motor unit failure. When contrasted to normal gait, missing muscle force should pinpoint nerve deterioration.

The method presented in this study was shown to be capable of transmitting stored acquired data from reading shear and compressive reaction forces from the sole of the foot as a function of time. This information was in a format suitable for a spreadsheet and analyzed via finite element analysis.

The design had three major parts: the transducer, data storage, and computational prediction. The transducer consisted of a network of 28 elastomeric resistors (per foot) placed under the foot in the shoe on key areas of shear and compressive stress. These particular resistors consisted of rubber of an appropriate modulus infused with a carbonaceous inorganic semiconductor, thus allowing a quantitative conduction function of compression. The resistances were sampled by a microcontroller with a clock-based timer to record each RC discharge. The firmware was essentially programmed to output one 5V pulse (=digital true) and time the return input until a reading of 1.5V (= digital false). As long as the resistance and capacitance was kept small, each time record was a multiple of two microseconds. After a serial data transfer, the stored data was used to model vectors of insole force to stress and strain in tendons, revealing muscle contraction force.

Results of testing and further research in the design revealed several inconsistencies in performance. First, the elastomeric resistors were non-linear in nature and naturally unreliable. Secondly, with a multitude of I/O, the microcontroller must have a faster interpreter. This processing time often limited resolution to about 14 per second upon testing. Assuming the gait cycle is about 0.5 seconds, 50 samples per second corresponds to a minimum time resolution. The optimal design would use a more capable microcontroller and a fiber optic transducer that senses deflection of light under the sole as an indication of deformation. More durability and portability would allow real life data to be taken over many different strides to directly pinpoint nerve deterioration. Noting this, the final design should have a hip pack to receive and store data transmitted wirelessly from a lightweight attachment on the side of each shoe.

This study was conducted at the Tulane University Biomechanics Lab and supported through the Biomedical Engineering Department.

Development of a Computer Model of Aircraft Flight for Use in Flight Control Systems

Casey J. Ronayne

Advisor: Sergey V. Drakunov, Ph.D.

Property and lives can be lost when aircraft pilots do not react quickly enough in extreme situations. Aircraft pilots face many situations where extremely quick reflexes are necessary to preserve the welfare of their crew and cargo. If a system casualty occurs, such as an engine failure or stall, resulting in loss of control, the pilot has a limited amount of time before the aircraft will be unrecoverable. It is proposed that if a system was implemented to stabilize the aircraft during the reaction time of the pilot, many accidents could be prevented. To accomplish this, a computerized control system, based on a model of aircraft flight, is linked to the autopilot system of an aircraft. The control system monitors the aircraft's status and, if it recognizes a situation that could result in loss of control of the aircraft, makes the necessary control inputs through the aircraft's autopilot system. The purpose of this study is to complete the first step in creating a flight control system like this, the development of a computer model of aircraft flight.

A model of aircraft flight was developed using a software package for modeling, simulating, and analyzing dynamics systems called SIMULINK[®]. The model uses block diagramming to model the seven basic equations of aircraft flight set forth in *The Control Handbook*, by Pachter and Houppis. These seven equations describe the bank angle, angle of attack, sideslip angle, and roll rate, pitch rate, yaw rate, and the perturbations in the angle of attack of an aircraft in flight. Each of these equations was first solved for the desired term, and then programmed into SIMULINK[®]. The equations were in the form of rates of change, so the output of the block diagrams was integrated to provide the desired term values for the model. In addition, many of the equations for the terms rely on their output as well as the output from other equations, so the outputs of several of the equations had to be routed back in to the beginning of the equations for use in subsequent iterations.

The model performs as expected. It has a generalized format that allows input of different control coefficients that would correspond to different aircraft. This way, the model can be used to create control systems for a number of different aircraft by simply entering the appropriate control coefficients for certain aircraft.

The next step in the development of a flight control system would include the creation of a feedback control system where the computer model takes input from the status of, and the environment affecting, the aircraft, and signals the autopilot system of the aircraft to make the necessary adjustments in the aircraft's control surfaces to increase the stability of the aircraft.

This project was supported through the Department of Electrical Engineering and Computer Science.

A Dynamic Model Of Calcium Homeostasis In The Body
Jayna Michelle Belt
Advisor: Eric Nauman, Ph.D.

The population of people aged 65 and older is growing at an increasing rate. For example, in 1900 the ratio of elderly people to the general population was 1 in 25, and in 2000 it was 1 in 8. Also, between the years 1990 and 2020, the population of people aged 65 to 74 is projected to increase by 74 percent. Because of this trend, the need for health care to cater to this populations needs is ever increasing. Osteoporosis, for example, threatens postmenopausal women more so than older men; however, this disease remains significant in both sexes. The causes of this disease are becoming better understood, and the more that is known about the causes of osteoporosis, the closer we come to finding adequate methods of treatment and prevention. The purpose of this study was to help conceptualize the effects of osteoporosis or any other calcium related disease in the body. We have developed a model that accounts for calcium transport and use in multiple systems of the body to produce relationships and feedback that will aid in the understanding of calcium function in the body as a whole.

Several systems were identified as significant to calcium balance in the body, they are: the gastro-intestinal tract, the renal system, the skeletal system, and blood and extracellular fluid. Each of these systems was researched extensively in order to find documented relationships involving calcium transport and use. Some of the equations and variables used in the model have been adapted from researched equations, while others have been taken from raw data in other studies. The equations for each system were programmed into MATLAB and integrated numerically to form the complete model.

All values and equations in the current model pertain to calcium homeostasis as related to rats in order to make the model applicable to future laboratory experiments. The results of the model were satisfactory in that they closely modeled the typical behavior of most of the systems involved. There are some inaccuracies concerning the behavior of interleukin-6 in the model; however, this can be attributed to how little is actually known about this cytokine and its relationship with the bone remodeling cells. Despite a few minor irregularities, the product is a working model that will help interpret physiological responses to diseases involving calcium.

Analysis produced by the model will be used for future laboratory experiments to facilitate verification and re-calibration of the working model. First, the model will be calibrated using data from work done by Dobnig, Hock, and Tam whose research considers bone resorption and/or formation due to parathyroid hormone dosing in rats. Then, when the model behaves appropriately to varied conditions and experimentation, it will be tested in the laboratory using live rats. It is probable that this experimentation will involve the effects of PTH levels and interleukin-6 on osteoclastic formation. Ultimately, the working model will be adapted to human specifications and will be able to be applied to diagnosis and treatment of calcium related disease.

This research was conducted in the Cell and Tissue lab at Tulane University Department of Biomedical Engineering through the use of MATLAB computational software.

Mechanical Analysis and Bone Adaptation in Scoliotic Spines

Sara Rumancik

Advisor: Eric Nauman, Ph.D. Advisor: Alan Burshell, Ph.D.

Scoliosis affects one in ten persons and two to three persons out of 1000 will need active treatment for a progressive condition (Source). The onset of idiopathic scoliosis most commonly occurs during adolescence and 90% of the patients are female. Many mathematical models and experimental analogs have been examined in an attempt to understand the reason for the onset of idiopathic scoliosis and its progression. To expand upon prior models, we are looking not only at the forces and moments of the vertebral column, but taking a closer look at the forces and moments developed at the individual vertebrae, specifically L1-L4. The purpose of this study is to investigate through statistical analyses of the bone mineral density data acquired from DXA and a mathematical model of the L1-L4 vertebrae in a scoliotic spine, the relationships between the mechanics of the spine and bone adaptation.

In this study, we analyzed 95 post-menopausal, non-osteoporotic female patients with ages ranging from 45-86. Through use of DXA, the bone mineral density on the concave and convex sides was calculated using two different methods. The first method was a “bisection” of the L1-L4 vertebrae. A vertical cut down the center of vertebrae was made and approximately 50% of the bone was deleted from the right and left side, alternately. The second method was a “trisection” of the L1-L4 vertebrae. A vertical cut down the right and left thirds was made, alternately, and the remaining two-thirds of the bone was deleted. By measuring the top and bottom angles of each vertebrae, the side under compression (concave) could be determined. T-tests were then run on the data to show significant difference between the concave and convex sides. A simple mechanical model was constructed which included axial force, shearing force, moment and the average angle of tilt of the vertebrae. The axial force, shearing force and moment were non-dimensionalized. The parameters of the constructed mechanical model (dimensional and non-dimensional) were compared against the concave and convex sides, in a simple linear regression, to examine possible contributions to the differences in densities between these sides. The most significant parameters in the linear regressions were run in multiple non-linear regression against non-dimensional BMD.

T-tests showed high levels of significance ($<.0001$) for comparison of the concave and convex sides in the bisected and trisected vertebrae. Results showed that non-linear analyses yielded significantly higher R^2 scores as compared to the simple linear regressions. It was also shown that shear force and angle of tilt of the vertebrae were the most important mechanical contributions to the difference in density between the concave and convex sides.

The results show that there is a significant increase in density between the concave and convex sides. The contributing parameters to the increase in density is shear force and average theta.

This project was supported through the Department of Biomedical Engineering and the Department of Orthopedics at Ochsner Clinic.

Bone Adaptation in the Scoliotic Spine with Osteoporosis
Robert Henry Routh
Advisor: Eric Nauman, Ph.D.

Scoliosis is a disorder in which a person's spine curves either to the left or right of the centerline of the body. Osteoporosis is a disorder characterized by an increased probability of bone fracture. This probability is increased by a decrease in bone mineral density. Bone mineral density can be measured using a dual energy x-ray (DEXA) scanner, which measures the area and bone mineral content of a bone and uses this information to calculate the bone mineral density.

For this study, the bone mineral densities of the spines of eighty-four individuals were recorded from DEXA scans of the lumbar spine (L1-L4) taken prior to the study. The scans were divided down the middle of the spine to separate the concave and convex sides of the spine. The scans were also trisected into concave, convex and center sections. For each cut and for the whole scan, the area, bone mineral content and bone mineral density were recorded. Along with these measurements, patient data including age, weight, height and age at menopause were recorded. The second part of data collection consisted of measuring the angle of each vertebra with respect to vertical. This angle was used to calculate the shear and normal forces. The horizontal distance of the centroid of each vertebra from the centerline was measured as well. This distance along with the patient weight was used to calculate the moment exerted on the vertebra created by the bending of the spine.

First, t-tests were performed to examine the difference in bone mineral densities on the concave and convex sides of the spine. This difference was significant. Second, all the data was analyzed using both linear and non-linear regressions. Using a linear regression, the data showed that there was a strong correlation between the difference in bone mineral densities on the concave and convex sides of the spine and the severity of the angle of curvature. A similar correlation was shown for both the measured distance and the moment versus the difference in bone mineral densities. Using a non-linear regression, it was shown that the shear force, moment, and the angle of curvature each had significant effects on bone mineral density. However, only the moment and angle of curvature were significant for bone mineral content.

It was shown that bone mineral density is higher on the concave side of a scoliotic spine than the convex side. This difference was shown to increase with the severity of the curvature of the spine and with the distance that the spine was offset from the centerline. This analysis suggested that the bone was adapting primarily to forces created by deformation and the moment. The moment proved to be the most significant indicator of the bone mineral content. The non-linear model created by this project could prove useful to physicians in predicting the BMD and BMC characteristics of the spine of patients with both osteoporosis and scoliosis. Additional testing should be done on spines with scoliosis but without osteoporosis. This information could be compared to the results from this study in order to better understand what the differences are between bone adaptation in osteoporotic and non-osteoporotic spines with scoliosis.

This project was conducted using DEXA scans provided by Ochsner Health Clinic.

Assessment of Morphological Variation in the Human Femur
Melissa Marie Banitt

Advisor: Glen A. Livesay, Ph.D. Co-Advisors: Trenton W. Holliday, Ph.D.; Kay C Dee, Ph.D.

A remaining question in the area of biomechanics is the potential influence of joint shape on joint function. This question stands in direct contrast to the fact that the concept of 'form follows function' is widely applied in biomedical engineering in studies of development and/or remodeling. An improved understanding of the interaction between form and function could substantially impact biomedical interventions to restore function to injured or pathological hip and knee joints. A requisite step in considering the effect of joint shape on function is the assessment of baseline data on human variability. Therefore, the overall purpose of this study was to perform a morphometric analysis on the human femur using the Procrustes method to establish the baseline shape and variability of the distal and proximal joint regions.

Programs for Procrustes analysis were developed and tested in *MATLAB* 6.0 matrix processor software prior to data collection. The programs incorporated the ability to examine data from two-dimensional digital photos, two-dimensional digitized points, as well as three-dimensional digitized points for the femur as a whole and the distal and proximal ends separately. A total of forty-one mathematical, anatomical and pseudo-landmarks were characterized for the femur, twenty-two on the proximal end and nineteen on the distal end. Twenty femurs were labeled, digitally photographed and digitized in 3-D with an Immersion MicroScribe 3-D Digitizing arm to enable direct comparison of photographic data (commonly done) and true 3-D landmark locations. Collected data were then run through the developed Procrustes method programs to determine the Euclidean Distances at each landmark in relation to the group of specimens and to a determined average shape. Comparisons were then made between the different methods used for data collection, and crucial landmarks were discovered in the process of establishing a baseline shape for the distal and proximal ends of the femur.

Anticipated results include the quantification of a baseline shape for the distal and proximal regions of the human femur, the identification of critical landmarks, and the outcome of comparisons between different methods for data collection. The quantification of a baseline femur shape will serve as a reference upon which comparisons to injured or pathological hip and knee joints can be made, in addition to being the first step in the development of a knee or hip joint form-function model. The identification of crucial landmarks will involve classifying each landmark as variable or invariable based on its relative Procrustes number. It may then be discovered that stable landmarks, or those with smaller variability within the human population, play more of a vital role in joint functionality. The comparisons made between the 2-D and 3-D, and photographic and digitized data Procrustes methods will determine which techniques are superior experimentally for use in future studies.

This project was conducted in the Biomechanics Lab within the Department of Biomedical Engineering and the Physical Anthropology Lab within the Department of Anthropology at Tulane University.

Extending Morphometric Analysis To Include Whole Joints:
Preliminary Application To The Knee
Megan M. Mickal
Advisor: Glen A. Livesay, Ph.D.

A large percentage of the population is afflicted with a form of knee injury at some point in their lives. While many of these injuries may be successfully treated and will heal over time, there are certain injuries that will be debilitating in the long run. Among these is ACL injury, which is routinely treated with surgical repair in active patients. Outcomes are generally good, but the relative inconsistency in the success of ACL reconstruction may be due to many different conditions, one of which is the variability in the shape of the knee joint from patient to patient. This raises an important question: is there a relationship between changes in joint shape and ligament properties and changes in the function of that joint?

The fundamental challenge of understanding the interaction between form and function at the human knee joint is that single bones allow for analysis of form, while two bones are required to analyze function of a joint. The overall problem of understanding the relation between shape and shape change and function at a synovial joint therefore requires that two fundamental questions be answered: 1) What is the variation associated with important shape landmarks at the knee joint? and 2) How can shape analyses from morphometrics be extended to enable consideration of joints? This thesis will focus on preliminary investigations toward the latter question, and develop an approach by which morphometrics could be extended to analyze changes in shape between synovial joints in the human body.

In this study, morphometrics, the process of identifying shape based on landmarks, was used to analyze data collected on the femoral and tibial insertion points of the major ligaments of the knee. There are many various types of analysis, including Cartesian transformations, the Procrustes method of analysis, Finite-Element Scaling Analysis, and Euclidean Distance Matrix analysis. This morphometric analysis provides the first step to possibly determine shape deformation due to a difference in function, which could lead to a better treatment, and possibly prevention of injury.

An Immersion MicroScribe 3-D digitizing arm was used to collect the coordinates of the tibial and femoral insertion points of the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and the lateral collateral ligament (LCL) of an idealized model knee. These insertion points were digitized 10 times on the model in extension to present multiple sets of coordinates for analysis. The coordinates were then subjected to anterior-posterior (A-P) displacement in 14 increments of 0.25 mm in order to evaluate the elastic and material properties of each ligament. With these properties, the relationship between the A-P displacement of the knee and the A-P load on the knee was graphically determined.

The results gathered through this testing and analysis provide a basis for a proposed theory of a type of “elastic morphometrics.” This concept incorporates both the classic morphometric analysis of motion within defined landmarks and the mathematical analysis of the elastic and material properties of an element. This notion of “elastic morphometrics” may potentially provide a method of understanding the relationship between shape and shape change and the corresponding function of a synovial joint.