SECOND ANNUAL RABI SCHOLARS SYMPOSIUM
Saturday, November 10, 2007

Oral Presentations: 11:00 a.m. to 12:10 p.m. and 3:15-4:07 p.m. (Schermerhorn 614)
Poster Session: 1:15-3:15 p.m. (Schermerhorn 603)

11:00 a.m.	Welcome
11:05 a.m.	Thomas Dumitrescu The Large Hadron Collider and Challenges for Particle Theorists
11:18 a.m.	Geoffrey Fudenberg Transport in Suspended Graphene Devices
11:31 a.m.	John Hwang Copulation Calls in *Macaca fascicularis*
11:44 a.m.	Dmytro Karabash A Modification of the Sarkar-Wang Algorithm and an Analysis of its Computational Complexity
11:57 a.m.	Yao Liu A Geometrical Formulation of Electromagnetic Radiation of a Moving Charge
12:10 p.m.	Lunch break (Schermerhorn 603)
1:15 p.m.	Poster session
3:15 p.m.	Yun Liu Phase Transitions in the Quantum 2D Ising Model
3:28 p.m.	Charles Macanka Visualizing and Manipulating Georeferenced Data in an Augmented Reality Environment
3:41 p.m.	Vedant Misra Multithreading and SIP Simulation in the E-B Experiment
3:54 p.m.	Scott Simonovich Phosphine Promoted Cyclization Reactions for the Synthesis of Natural Product Substructures

RABI SCHOLARS (ORAL PRESENTATIONS)

DUMITRESCU, Thomas

The Large Hadron Collider and Challenges for Particle Theorists

The Large Hadron Collider (LHC) at CERN in Geneva, Switzerland is the largest scientific apparatus ever built. By colliding bunches of protons and antiprotons at the cosmic energy of 14 TeV, it will allow us to probe the most mysterious aspect of the so-called Standard Model of particle physics – the Higgs mechanism, responsible for giving elementary particles mass – as well as possible extensions of the Standard Model, such as Supersymmetry or extra dimensions. LHC collisions are incredibly complicated – they can involve many hundreds of particles – and precise measurements are only possible after scrupulous background rejection. Consequently, experimentalists have published a "wish list" of Standard Model processes to be calculated by theorists to a high level of accuracy. After outlining the importance of these processes, I will explain why such calculations are exceedingly difficult, and briefly introduce some modern methods for tackling them in spite of all odds. I will conclude by reporting on an ongoing calculation by Michael Peskin and myself of the tree-level QCD amplitudes for top quark production and decay with radiation of arbitrarily many positive helicity gluons.

FUDENBERG, Geoffrey

Transport in Suspended Graphene Devices

In physical sciences, control of novel experimental systems provides the means to exciting discoveries. By confining electrons to two-dimensions, fascinating quantum mechanical influences on transport can be observed, including the

quantized Hall effect. The recent discovery of graphene has been experimentally remarkable as a nearly ideal two-dimensional system, with exceptionally high quality crystal structure and single-atom thickness. Besides its status as experimental wunderkind, graphene has been subject to theoretical investigations for the past half century. In order to obtain a view of the physics of graphene that is unobstructed by interactions with the substrate, we have worked on fabricating suspended graphene as we have reason to believe this will improve transport. Preliminary results indicate improvements in mobility. Our technique for graphene suspension involves the standard micromechanical cleavage of bulk graphite [Novoselov et al., 2005] onto a layer of SiO_2, which lies on top of a Si wafer. Using nanolithographic techniques, we contact the graphene sample with gold electrodes. Finally, we etch away SiO_2 until the graphene sheet hangs freely.

Un-intuitive interplay of forces at small distances poses serious challenges to nanoscale fabrication. In particular, to measure the properties of suspended structrues, they must remain suspended. We believe there are at least two effects contributing to collapse of our suspended graphene samples. The first results from the electric force due to a capacitive effect between our back gate and the graphene sample. The second relates to water, which, if stuck under the sample may cause collapse upon evaporation.

Novoselov, K. S., Jiang, D., Booth, T., Khotkevich, V. V., Morozov, S. M., and Geim, A. K. (2005). Two dimensional atomic crystals. PNAS, 102:10451.

HWANG, John

Copulation Calls in *Macaca fascicularis*

Females of many primate species – including those of *Homo sapiens* – emit prominent vocalizations during copulation, whose function or functions are unknown. It is generally assumed that these copulation calls have evolved in order to benefit the female in some way; for example, the calls may serve to attract and incite physical competition amongst other males in order to select for the fittest father; alternatively, this congregation may lead to insemination by multiple males, which would allow the female to confuse paternity and thus discourage infanticide. It has been proposed that the temporal and spectral characteristics of the calls themselves may encode relevant information; perhaps most intuitive is the idea that these are honest signals of female fertility, directed primarily at the copulating male. We have been collecting such temporal and spectral data from a large set of prerecorded calls from the Old World species *Macaca fascicularis* (crab-eating macaque) in order to see if these parameters relate to the female's ovarian phase. A preliminary examination of some of the parameters we used does not support the existence of such a relationship; however, further study is needed in order to exhaust the sheer number of potential temporal and spectral characteristics of a call which may serve as acoustic cues, as well as to determine the effects, if any, of the presence of ejaculation and male rank.

KARABASH, Dmytro

A Modification of the Sarkar-Wang Algorithm and an Analysis of its Computational Complexity

Heegaard Floer homology is an invariant of closed 3-manifolds that was developed by Peter Ozsváth and Zoltán Szabó. The knot version of this invariant, known as Heegaard Floer knot homology. The original construction of Heegaard Floer homologies required solving a system of partial differential equations. Recently two combinatorial algorithms were developed. The first algorithm, created by Ciprian Manolescu, Peter Ozsváth and Sucharit Sarkar, computes the Heegaard Floer knot homology HFK. The second algorithm, created by Sucharit Sarkar and Jiajun Wang, computes (HF)^ and its knot version (HFK)^. Heegaard Floer knot homology distinguishes unkots and the two algorithms are the first combinatorial algorithms that are able to distinguish the unknot.

We first present analysis of computational complexity of the Sarkar-Wang algorithm, the modification of the algorithm and its complexity, and analysis of the computational complexity. Then we analyze combinatorial algorithm that calculates the Heegaard Floer Homology from a nice diagram. The highlight is main modification to the Sarkar-Wang algorithm, the stabilization procedure which produces distance 1 Heegaard diagram, which makes the algorithm asymptotically faster (in terms of complexity of knots). We conclude with a conditional theorem, which suggests that the modified Sarkar-Wang algorithm is faster than the Manolescu- Ozsváth-Sarkar algorithm.

*Acknowledgement: This talk is based on research conducted together with Jonathan Hales and Michael T. Lock in the summer of 2007 under supervision of Robert Lipshitz and Thomas Peters. I would also like to acknowledge our close work with the other research group composed of Yael Degany, Andrew Freimuth and Edward Trefts.

LIU, Yao

A Geometrical Formulation of Electromagnetic Radiation of a Moving Charge

The Maxwell's equations are completely solved for the case of a moving point charge, and it is well known that accelerating charge radiates. The electromagnetic field generated is known as the Liénard-Wiechert field. However, it is usually very difficult to solve analytically except for a few simplest cases. The difficult part is to solve for the retarded position and retarded time at which the information of the motion of the charge leaves the charge and propagates out at the speed of light. The new formulation takes as the starting point the position and time of emission, and considers all possible field positions and times. It is essentially a reparametrization of space-time by the future light-cones along the trajectory of the charge, turning three dimensions of space and one dimension of time into two of "direction" and two of times. The electric field at a given point and time is encoded in that parametrization. This formulation is more visually intuitive, and is particularly useful in the computer simulation of it.

This research is incomplete. The calculation of the electric field does not fully agree with the Liénard-Wiechert field. Furthermore, one would hope that the magnetic field could also be derived from this formulation, without the Maxwell's equations. The advanced solution can be similarly formulated, and one would ask the question how it relates to Feynman-Wheeler theory of radiation reaction force.

LIU, Yun

Phase Transitions in the Quantum 2D Ising Model

Many problems in condensed matter physics concerning phase transitions may be analyzed through lattice models, observing the statistical effects generated by various interactions between the lattice elements. Such examples include the classical Ising model of the magnet, which explained the phenomenon of spontaneous magnetization as temperature decreases (sudden alignment of otherwise randomized spin orientations); and have been abstracted to models for density fluctuations and liquid-gas phase transformations.

This summer, I studied in detail the problem of quantum phase transitions in the 2D Ising Model, which, similar to the classical Ising magnet, exhibits a spontaneous phase transition as the system undergoes temperature change. The question to be answered, however, is whether such a phase transition occurs as a first-order or second-order phenomenon. The properties of the phase transition may be gathered by studying the partition function, a mathematical construct in statistical mechanics; discontinuities in the derivatives of the partition function indicate whether or not the transition is first or higher order.

Since analytical solutions to such models are often difficult, the problem becomes one of numerical simulations, which introduces unfortunate losses of generalization – specifically, the intractability of modeling lattices of large dimensions (much less the infinite-sized lattice such as that of the quantum 2D Ising magnet). Monte Carlo methods are utilized in inferring the statistical behavior of the finite system, and scaling methods are employed to produce the result at infinite lattice size.

MACANKA, Charles

Visualizing and Manipulating Georeferenced Data in an Augmented Reality Environment

Current tools for visualizing georeferenced data require indirect interaction for selection of individual data points or manipulation of a data set. Direct manipulation in augmented reality (AR) has been shown to improve comprehension and performance in information visualization tasks. In AR, the user wears both a head-worn, video see-through display that can superimpose graphical elements over the user's view of the physical world, and a video camera to acquire images that can be processed by computer. Data can be drawn around the user in relative or actual locations, allowing the user to explore the data through physical movement, and improving comprehension of spatial relationships among data points and between data and the environment. In this project, we investigate a system supporting direct manipulation of georeferenced data visualizations in a tangible AR.

The system is designed to work with any set of georeferenced data points; we used a database of geocoded plant samples collected at Plummers Island, MD, from our Electronic Field Guide Project. The user interacts with the data through a Personal Interaction Panel (PIP), a virtual panel, drawn relative to a printed marker held by the user. The PIP has two display modes. The first is a world-in-miniature representation of the data, which is an overhead view of an area that is scaled down to fit on the panel. The entire data set can be manipulated by moving the printed marker.

The user also holds a selection wand, a rectangular box with markers on its sides. It projects a virtual ray that selects the part of the PIP it touches. The user selects data points on the panel with the wand and then switches to the PIP's second display mode, which provides additional information about the data point. We found through informal testing that the selection wand as an input device is difficult to use when the camera has a small field of view. Observations from our initial prototype will be used to inform the design of the next version of the system.

MISRA, Vedant

Multithreading and SIP Simulation in the E-B Experiment

The E and B EXperiment (EBEX) is a NASA-funded, balloon-borne experiment that will observe Cosmic Microwave Background (CMB) polarization over a range of scales. The sensitivity of EBEX's measurements will be sufficient to measure or place an upper limit on the polarization signal generated by inflationary gravitational waves. The Miller lab is building and implementing the attitude control system for the EBEX apparatus; a single flight control program (FCP) manages software threads that, among other things, receive and record data from the bolometers. At the start of the summer, FCP failed to function when used in its multithreaded capacity. This problem was debugged. A support instrument package (SIP) simulator is provided by the Columbia Scientific Ballooning Facility (CSBF, formerly the Nasa Scientific Ballooning Facility), to allow experimenters to interface research equipment with on-site navigational equipment provided by NASA. The SIP simulator's communications protocol was used to begin testing the interface between the flight equipment and ground stations.

SIMONOVICH, Scott

Co-author/mentor: Erik J Sorensen

Phosphine Promoted Cyclization Reactions for the Synthesis of Natural Product Substructures

Natural products are a rich source of pharmaceutically applicable compounds. Extracts from nature are known to display biological activity against HIV, malaria, and cancer; however, due to their low abundance in nature, it has proven useful to synthesize such compounds in laboratories for further biological testing. Efficiently achieving these targets requires novel transformations that construct great molecular complexity, as the length and cost of pathways contribute to their practical applications in industry. Phosphines allow for this rapid construction of complexity as a result of their ability to form carbon-carbon bonds by readily engaging and disengaging molecules. Specifically, phosphines are useful reagents for forming ring structures found in many natural products. Three such targets that possess ring complexity are Lysergic acid, Cortistatin A, and Kalihinol C, of which the latter two possess biological activity against cancer and malaria, respectively. The viability of three phosphine-promoted cyclization reactions was explored to generate substructures of these three targets. The transformations include a three component coupling, annulation, and Michael addition. Although the coupling and annulation reactions were ultimately shown to be unviable strategies, the Michael addition to a vinyl phosphonium species, followed by a ring closure, proved to be feasible. This strategy may be employed in the future to selectively generate carbon-carbon double bonds of desired geometry in Kalihinol C and to construct the challenging [3.2.1]oxabicyclooctene ring system of Cortistatin A. However, further optimization studies are required before this method can be practically employed in synthesis.

RABI SCHOLARS (POSTERS)

AGNE, Michael R.

Co-authors/mentors: Stephan A. Mackowiak, Laura J. Kaufman

Investigation of the Influence of Probe Structure on the Dynamics of Supercooled Liquids

To investigate the interesting dynamics of glassy systems, it is often necessary to add probe molecules, which are easily monitored, to the glassy system. However, relatively little attention has been given to the question of whether such probes may actually alter the dynamics of the surrounding molecules and thus not report on the dynamics of interest. To investigate this question, we employ molecular dynamics simulations in glassy systems bearing a probe. Here, unlike in experiment, both the host particles and the probe can be monitored. The simulations performed employ a binary Lennard-Jones model glass system containing a non-spherical rough probe (meant to mimic the common probe molecule terrylene). The probe's influence on the dynamics of the surrounding system is evaluated via analysis of the Debye-Waller (DW) factor, which is the variance of the mean square displacement of the system.

The dynamics of the particles surrounding the probe are investigated as a function of position. Those particles above and below the probe are termed “parallel” particles and those to the side are termed “perpendicular.” It is found that molecules oriented parallel to the probe are slowed significantly compared to the bulk particles, those far from the probe. The molecules perpendicular to the probe and in the first three neighboring shells experience a smaller, albeit noticeable, slowing effect. We hypothesize that the slowing down of the particles is caused by the rough surface of the probe.

CHOU, Kevin

Co-author/mentor: Andrew Gelman

Statistical Modeling in Political Stereotyping: Purple America

The Democratic Party has traditionally been viewed as the party representing the lower classes and the Republican Party as the party for the wealthy. However, recent presidential elections reveal that Democrats have actually been doing better in the richer "blue" states in the northeast and west coast, while Republicans control the "red" states in the middle of the country. Varying-intercept and varying-slope multilevel models, which simultaneously show within-group and between-group patterns, were used to understand the relation between income and vote among individuals, counties, and states. It was observed that even though high-income voters still continue to vote Republican, higher-income states support the Democrats.

Affiliation with political parties may be associated with personal attribute stereotypes, some of which may or may not be statistically accurate. To determine what people consider most when assessing an individual's political affiliation and how they interpret this information; a pilot study was carefully created and implemented. Profiles were randomly generated using data from the 2004 National Election Studies, a nationwide survey of the American electorate. Presented as an online game, the profiles were provided to players who were then asked to decide whether they thought the person described was a Democrat or a Republican.

Using the data collected, procedures include creating a logistic regression, which incorporates as the parameters, all attributes of an individual. This allows for insight into political stereotyping by assigning a probability or likelihood value of being part of a specific political affiliation to any combination of traits. This reveals which characteristics people consider to have the greatest utility and weight when judging a person's political affiliation.

CHOY, Megan

Co-authors/mentors: Paul A. Marks, Raphael Parmigiani

Effects of Histone Deacetylase Inhibitors on Cancer Cell Motility

Metastatic cancers are difficult to treat because of their aggressive ability to spread undetected throughout the body. Breast and prostate cancer are common types of cancers that frequently metastasize. It has been previously shown that some histone deacetylase inhibitors (HDACi) can decrease cancer cell motility by affecting acetylation of tubulin, a known HDAC6 target. For this study, metastatic breast epithelial carcinoma cell line MDA-MB-231 was compared to metastatic prostate adenocarcinoma cell lines LNCaP and LAPC4. Specifically, *in vitro* cell motility and HDACi sensitivity studies of MDA-MB-231 were compared to the migration and sensitivity of LNCaP and LAPC4. Migration chamber assay results showed that HDACi’s affecting HDAC6 were associated with decreased cell motility. However, inhibiting class I HDACs with MS-275 did not inhibit cell migration in $HDAC^{+/+}$ cells. MS-275 inhibits class I, but not class II (HDAC6) HDACs. Further experiments are needed to determine why cell migration was not inhibited with class I HDACi MS-275 in $HDAC6^{+/+}$ cells. Experiments of LNCaP and LAPC4 in mouse model systems are also needed to examine *in vivo* metastasis for prostate cancer.

GURNANI, Lalit

Studies of Autoimmunity

Autoimmunity has been implicated in the pathogenesis of several human endocrine disorders, including Type 1 (juvenile-onset) diabetes mellitus, Hashimoto’s thryoiditis, Type 1 polyendocrine autoimmune failure, and Graves’ disease. Graves’ disease is an example of an autoimmune disease in which a spectrum of circulating autoantibodies to thyroid stimulating hormone (TSH) and other putative cell surface receptors causes abnormal growth and hyperfunction of the thyroid gland, exopthalmos, and less commonly pretibial myxedema.

Multiple endocrine neoplasia type 1 (MEN1) is a benign form of neoplasia characterized by hyperfunction and tumors of the parathyroid, pancreatic islets, and anterior pituitary glands. MEN1 is caused by an inherited mutation in a tumor suppressor gene called menin, located on the long arm of chromosome 11, region 11q13. Studies using cultured parathyroid-derived and endothelial cells also suggested a role for a circulating growth factor (possibly of pituitary origin) in MEN1. One such growth factor, basic fibroblast growth factor (FGF) is not normally found in human plasma and may trigger an autoimmune response in susceptible individuals. Some antibodies may mimic the effects of the growth factor and thereby contribute to disease manifestations, i.e. tumor growth and new blood vessel proliferation that favor tumor spread or metastases. Such fibroblast growth like autoantibodies were reported in a subset of patients with clinically aggressive, prolactin-secreting pituitary tumors and multiple endocrine neoplasia type 1. FGF-like growth promoting autoantibodies was then found in subsets of patients with growth hormone-secreting pituitary tumors and in a subset (10%) of patients with clinically aggressive breast cancer metastatic to bone. Tumors from patients with multiple endocrine neoplasia type 1, and subsets of patients with growth hormone producing tumors and aggressive breast cancer may share one or more common genetic mutations, which may contribute to tumor progression. In addition, prolactin is an established growth promoter for breast cancer in animals and basic fibroblast growth factor contributes to growth of human breast cancer cells in vitro.

Since fibroblast growth factor has also been implicated in thyroid cell proliferation and goiter, we were interested in testing for the occurrence of fibroblast growth factor-like autoantibodies in Graves; disease, and its possible correlation with extra-thyroidal disease manifestations such as ophthalmopathy.

In 6/12 Graves' disease sera, there was significant endothelial cell autoantibody activity ranging from 121-159%, mean 146%. Three of six patients with endothelial cell associated GD-IgG had ophthalmopathy. The other three patients with endothelial cell autoantibodies had active Graves' hyperthyroidism without ophthalmopathy. There was no overall correlation between endothelial cell growth stimulatory autoantibodies and thyroid stimulatory immunoglobins (TSI) suggesting that endothelial cell autoantibodies differ from TSI. Anti-fgf antibody had no effect on endothelial cell autoantibody activity of one patient with severe Graves' ophthalmopathy. However, anti-fgf antibody completely neutralized endothelial cell autoantibody activity in serum from one patient with autoimmune thyroiditis and hypothyroidism.

These results suggest that endothelial cell autoantibodies may occur in a broad spectrum of autoimmune thyroid disease including Graves and Hashimoto's autoimmune thyroiditis. The growth factor receptor specificity (FGF vs other endothelial cell active growth factor) of such autoantibodies may differ in different disease conditions.

Prior work from Dr. Terry Smith's laboratory, Dept of Molecular Medicine, UCLA School of Medicine suggested that 1) expression of IGF-1 receptor in local eye fibroblasts is specific for GD patients vs normal's; 2) the pool of GD autoantibodies in addition to containing TSI also contains IGF-1 receptor stimulatory autoantibodies; and 3) circulating IGF-1 receptor autoantibodies and local expression of IGF-1 receptor in GD orbital fibroblast are both required for Graves ophthalmopathy.

Our findings of a lack of correlation between TSI and endothelial cell autoantibodies in GD are further support for circulating autoantibodies with additional growth factor receptor specificity (from TSH receptor alone) in Graves disease. In preliminary experiments we tested whether endothelial cell growth stimulatory antibody activity from patients with GD could be neutralized by specific anti-IGF-1 antibodies. However, the results were equivocal in part because of lack of suitable monoclonal IGF-1 receptor antibodies (we used polyclonal sera which at baseline caused stimulation of its own). We also obtained preliminary results (using specific anti-VEGF antibodies) suggesting that some of the stimulation from Graves' ophthalmopathy IgG in endothelial cells may be due in part to activation of the VEGF receptor- although these experiments also need to be repeated owing to similar baseline stimulation by polyclonal anti-VEGF antibodies alone. These polyclonal antisera may contain antiidiotype antibodies which at certain dilutions of the antisera cause some endothelial cell stimulation. This may be similar to the mechanism of spontaneous development of FGF-like growth stimulatory autoantibodies, i.e. via an idiotype, antiidiotype network of interactions which result from aberrant expression of circulating bFGF in a number of endocrine tumor disorders. In future experiments we plan to use monoclonal antibodies specific for these two receptors (VEGF, IGF1) to test the growth factor specificity of the endothelial cell stimulatory autoantibodies in Grave's disease. It is possible that autoantibodies with additional specificity may exist in GD serum and may contribute to either eye disease manifestations and/or angiogenesis associated with thyroid cell proliferation.

HORLBECK, Max

Elucidating the Hst1-Rfm1 Binding Site in Yeast

This summer I investigated the mechanism by which yeast (*S. cervisiae*) protein Hst1binds to its DNA-binding cofactors, Sum1 and Rfm1, thereby repressing (preventing transcription of) genes involved in sporulation. "Repression" is gene-specific and directional, in contrast to "silencing," in which regions of the genome thousands of bases long are made transcriptionally inactive. Silencing is carried out in yeast by Sir2 (Silent Information Regulator), and in humans by SirT1/2 and HDAC. Although silencing and repression are identical in biochemical mechanism (removal of an acetyl group from the histone tail), they are different in specificity. By investigating how Hst1 binds to its cofactors, we can explore what causes these different specificities. Single amino acid substitutions were made in a chimera protein of Hst1-Sir2, which can both silence and repress. Each mutant was tested for silencing in a yeast stain containing a gene which, when expressed (not silenced) in certain conditions, would produce a compound toxic to the cell. Each mutant was also tested for repression with a β-galactosidase assay; if a certain marker gene was de-repressed, it would produce a quantifiable color change in solution. Mutants that showed de-repression but continued to silence were hypothesized to be involved in Rfm1 binding. To confirm this hypothesis, the mutant proteins were co-immunoprecipitated with Sum1 and then the precipitate was run on a Western blot to detect the presence of Sum1. Absence of Sum1 on the blot was consistent with de-repression results, confirming that the amino acids changed were vital for Sum1-Rfm1-Hst1 complex. When the overall results were visualized using protein modeling software, the four amino acids required for binding were adjacent to each other on the surface of the protein, while amino acids with no shown effect surrounded them, forming what appeared to be a compact, clearly defined binding site. Elucidation of the Hst1-Rfm1 interaction is one part of a larger effort to investigate the biochemistry of histone deacetylases, which have demonstrated links to longevity, metabolism, and cellular differentiation.

OH, Chang Hyun

Chemically Removing Scotchtape Glue on Graphene Sample

Single-layer graphite (grapheme) is a subject of great scientific interest since it shows distinct chemical and electrical properties from bulk graphite. Graphene sheets can be manipulated chemically so that they can be used to study mechanisms of chemical reactions, using devices such as STM (Scanning Tunneling Microscope) or AFM (Atomic Force Microscope). The "Scotchtape method" can be used to prepare graphene samples on non-conductive materials such as silicon wafer. In this method, bulk graphite flake is placed on a strip of Scotchtape and peeled several times by folding the strip. Then this strip is pressed on silicon wafer to place graphene sheet on the wafer. This method is widely used because it is cheap and makes larger pieces of graphene compared to other methods. However, in chemical researches, the remnants of Scotchtape glue polymers can produce undesirable effects.

In this research, the focus was on removing the Scotchtape remnants chemically. Since we had problems figuring out the chemical structure of the Scotchtape glue polymer, various kinds of chemicals – organic solvents including acetone, chloroform, toluene, xylene, and mixtures of them, acid and base, and commercial glue remove – were used.

The result was not very satisfactory. Either the chemical did not have any effect on glue or it damaged both the glue and the graphene, most of the time more severely damaging graphene. This suggests relative stability of the glue polymer. As of now, since the knowledge about the glue polymer is restricted, continuing to try other kinds of chemicals does not seem plausible. I suggest that the focus should be on coming up with a new method of preparing graphene samples on non-conductive surface, or using chemically less stable glue.

SCHUBMEHL, Caitlin

The Role of SM-20, NIPK, and DP5 in Apoptosis

Neuronal cell death occurs by a process called apoptosis, both as a normal part of brain development and as a destructive result of injury or disorders. The pathway by which cell death occurs (in other words, what genes are involved and how they coordinate cell death) is still poorly understood. Three genes, SM-20, NIPK, and DP5, are thought to contribute to the death pathway, but the mechanism behind their role in this pathway is not yet known. In order to understand what role SM-20 plays, knockdown of SM-20 was achieved by a process called RNA

interference. In this process, a shRNA (short hairpin RNA) oligonucleotide was constructed, which included both sense and antisense sequences from the target gene (SM-20), meaning it was able to bind to targeted mRNA's and prevents the SM-20 gene from being expressed. In order to do this, it was first cleaved by restriction enzymes into smaller siRNA (short interfering RNA). This siRNA was bound to homologous mRNA (mRNA with a base sequence that is similar to that of the siRNA), thus blocking expression of the target gene, SM-20. Blocking the expression of SM-20 allows us to answer two questions; first, whether SM-20 is in fact involved in apoptosis, and if so what role it plays in this process. The results for this are still in progress. PCR amplification of SM-20, NIPK, and DP5 was also performed; in this process, the target genes were exponentially increased, inserted into plasmids, and the plasmids were transformed into (or taken up by) bacterial cells which will be used in later experiments. Uncovering the function and role of SM-20, NIPK, and DP5 in the death pathway will lead to a better understanding of the mechanism by which apoptotic death in neuronal development operates. It could also have implications for Alzheimer's disease, ALS, and Parkinson's disease since the cell death that occurs in these diseases and that which occurs in neuronal development is thought to follow a similar pathway.

TANDON, Olivia

Simulating Lek Behavior of the Lesser Bird of Paradise

This summer I continued my research project on the Lesser Bird of Paradise *Paradisaea minor*. The lesser bird of paradise are lek breeders, and "have long figured as prominent examples of sexual dimorphism and unusual mating behaviour" (Frith and Beehler, 102). Last summer, I completed general ethological studies on the behaviors exhibited by the birds of this species living in the World of Birds and the Conservation Building at the WSC Bronx Zoo, New York. I focused especially on the display and courtship behaviors of adult and juvenile males, and female responses to this behavior. This summer I continued these studies, and collected and analyzed video footage from multiple sources to examine display behavior in the wild and compare it to the observed behavior. I also worked on a project involving training the birds to pull a string to get a reward. Towards the end of the summer, I built a second training box, which I used, and am currently using, to test the birds' preference for different types of rewards. The boxes are distinguished by the color of the landing platform, with plain wood signifying a food reward and a blue platform signifying a non-food enrichment item, in this case several beads tied to a string. This project will be continued and eventually will be used to transition the birds to pulling a string to receive video of wild males displaying. I will then be able to test different theories of lek behavior, such as how the structure and hierarchy of the lek plays a role in the eventual mating percentage for each bird.

Frith, Clifford B. and Bruce M. Beehler. The Birds of Paradise. New York: Oxford University Press, 1998.

YANG, David

Co-authors/mentors: Deborah Smith, Mary Pulling, Jack Norton

Nontoxic Transition Metal Hydride Catalysis for Radical Cyclization

Radical cyclization, invaluable for natural product synthesis in the laboratory, has not been industrially useful because of its reliance on toxic organotin reagents. The Norton laboratory is developing nontoxic transition metal hydride catalysts, and has successfully afforded cyclization products by using the catalysts with various cyclization substrates. Hydrogen-deuterium exchange was used to confirm the mechanism is through a radical hydrogen atom transfer.

The van der Donk laboratory at the University of Illinois at Urbana-Champaign yielded its own cyclization products using Vitamin B_{12} as the catalyst, but no mechanism was proposed. The Norton laboratory believes the reactions occur through the same hydrogen atom transfer. In order to prove this, two substrates originally prepared in the van der Donk laboratory were synthesized and treated with a Norton laboratory catalyst, whose methodology is already known to be hydrogen atom transfer. If the same cyclized products are observed, then the van der Donk reactions likely also involve hydrogen atom transfer.

For the first dimethyl substrate, proton and carbon NMR revealed a single product that did not match the desired cyclized product. Analysis of the second diphenyl substrate reaction revealed multiple products that have yet to be characterized. The fact that the cyclized product was not observed with the first substrate does not rule out the possibility of hydrogen atom transfer. A separate reaction (namely hydrogenation) is probably occurring faster than cyclization. Additional experiments with varying conditions and catalysts are needed to determine the mechanism, whose understanding can open the possibility for further development.

YIO, Jiang

Co-author/mentor: Jing Lin

The Role of Short-Chain Fatty Acids in Necrotizing Enterocolitis

The project is part of a larger study of necrotizing enterocolitis (NEC) in newborn babies. It has been observed that some newborns develop NEC after exposure to food. NEC, which mostly affects premature infants, involves severe inflammation that causes destruction of bowel tissue. The phenomenon may be linked to short-chain fatty acids (SCFA's) in the food or generated during digestion. While the production of SCFA's in the intestinal lumen may promote intestinal barrier function, overproduction or overabundance may induce severe intestinal epithelial cell apoptosis (programmed cell death) and disrupt intestinal barrier function. Previous studies have shown that the growth of immature intestinal epithelial cells is enhanced by the presence of physiological levels of butyric acid (a SCFA) but disrupted by high concentrations of butyrate. These effects of butyrate can be inhibited by controlling parts of the pathways allowing butyrate to lead to cell death. In this project, the effects of different concentrations of butyrate are observed on relatively mature cells that have undergone several weeks of differentiation. In the mature intestinal epithelial cells, the rate of growth appears to correspond directly to the concentration of butyrate present. High concentrations of butyrate, instead of disrupting growth, actually promotes growth. This corresponds with the observation that NEC typically occurs within the first two weeks of life.

There is a strong implication of the role of short-chain fatty acids in the onset of necrotizing enterocolitis. Future study of the pathways involved may provide further insight into the mechanisms and treatment of NEC.

FOSTOR: FRONTIERS OF SCIENCE TRY-OUT RESEARCH (POSTERS)

ARCHIBONG, Belinda

Co-authors/mentors: Ray Sambrotto, Bob Newton

Measuring Net Community Production with An Oxygen Budget in the Hudson River

The objective of this project was to determine the applicability and limitations of measuring net community production (NCP) with an oxygen budget in the Tappan Zee/Haverstraw Bay (TZ/HB) region of the Hudson River. NCP reflects both photosynthesis (which produces oxygen) and respiration (which consumes oxygen). Oxygen in turn is a master biological variable in aquatic environments that determines habitability for numerous organisms, and it is influenced by additional factors such as nutrient additions to the river, wind and temperature. An oxygen budget constructed along this section of the river provides information on oxygen levels and changes in those levels. This involves an assessment of the benthic environment, including organism abundance and sediment oxygen consumption rates in the surface and deep regions of the main channel as well as the shallow margins and tributaries. It was discovered that the TZ/HB region has an unusually high percentage of depositional area. Such areas are inhabited by abundant benthic organisms. These benthic communities consume about $2.4 * 10^6$ mols of oxygen per day over the summer, and 2% of all the oxygen in the TZ/HB region per day during the summer season. This analysis also determined that both photosynthesis and respiration are involved in determining the oxygen levels and the ecological health of the TZ/HB study region.

CHATURANTABUT, Saireudee

Co-authors/mentors: George Ellestad, Nina Berova, Koji Nakanishi

CD studies on porphyrin-DNA conjugate

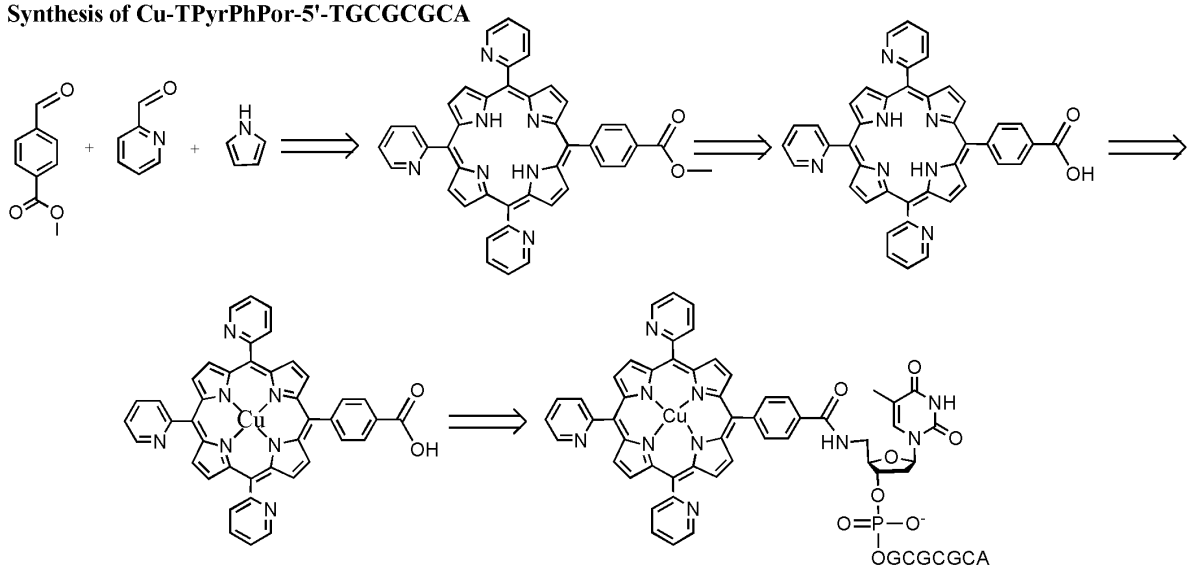
DNA is a polymorphic biopolymer that can adopt multiple confirmations including the classical B-form double helix and other non B-DNA structures such as left-handed Z-DNA, cruciform DNA, hairpins, triplex and quadruplex DNA. Small molecular probes have been used to study the transitions from one DNA conformation to another

Our goal was to synthesize porphyrin–DNA conjugates in which the porphyrin is joined by a 5’-acylamido linkage to a 5’-amino-derivatized oligonucleotide, TGCGCGCA, in order to study DNA transitions induced by environmental changes and drug binding using circular dichroism. Synthesis of the porphyrin-DNA conjugate yielded small amounts of the desired unmetallated product, but in addition, copper and zinc metalloporphyrin conjugates were also obtained. The origin of these metallated conjugates remained a mystery until it was realized

that either concentrated ammonia (a known source of trace metals) used to remove the assembled DNA from the synthesizer column and deprotect the DNA, or the HPLC purification conditions, or both, was responsible for the porphyrin complexation of the metals. Depending on the source of the ammonium hydroxide solutions, different ratios of the metallated species were obtained. This points to the need for caution in the synthesis of DNA-porphyrin conjugates and the use of concentrated ammonium hydroxide to de-block and remove the assembled DNA oligomers from the synthesizer column.

My effort involved primarily three parts: (1) the synthesis of the porphryin macrocycle and its conjugation to the DNA octamer. (2) the isolation and purification of the desired *meso*-tris(2'pyridyl)/(4'carboxymethylphenyl) porphyrin from the mixed aldehyde condensation reaction mixture of pyrrole with 2-pyridylcarboxyaldehyde and methyl 4-formyl benzoate (Rothmund-Longo conditions) using silica gel chromatography; and (3) HPLC purification of the copper porphyrin-DNA conjugate and its characterization by MALDI and UV visible spectroscopy.

Synthesis of Cu-TPyrPhPor-5'-TGCGCGCA



LACKO, Allison

Mobilization of Arsenic Contaminants

This project explores arsenic mobilization from aquifer sediments at the Vineland Chemical Company Superfund site in southern New Jersey. The site was heavily contaminated with organic and inorganic arsenic while the company was in operation, affecting underlying soil and an aquifer. Present methods of decontamination include soil washing and filtering the groundwater through a pump and treat system. The pump and treat system has experienced early tailing, however, and it may take several decades to reach the clean-up goal of 20 ppb As in the water. This tailing is due to arsenic binding with aluminum and iron in the aquifer sediment, causing it to leach into the groundwater. A proposed solution to this problem is to add chemical amendments to the groundwater to mobilize the arsenic. Two amendments tested in this project are 100mM oxalic acid and 100mM phosphate, which were run through a sediment column containing a contaminated soil sample.

LEWIS, Mia

Co-authors/mentors: Kevin Griffin, Stephanie Searle

The effects of New York's City's urban environment on the growth and physiological characteristics of *Quercus rubra*

Our experiments studied the effects of urban environments on a native plant species to understand how the environment responds to increased urbanization and global warming. Previous experiments have suggested that plant growth in New York City is higher than in surrounding areas. We measured growth and chlorophyll fluorescence in Q. rubra (red oak) along an urban-rural gradient from Central Park in New York City to the

Catskills, including sites at Lamont-Doherty Earth Observatory (LDEO) and Black Rock Forest. Additionally, we conduced a growth chamber experiment to test the isolated effects of nighttime warming in the city on plant function, mimicking diurnal and seasonal temperature patterns in Central Park and Black Rock Forest. Growth, chlorophyll fluorescence, gas exchange respiration and photosynthesis were measured. Data from the growth chamber experiments indicate that plants grown at city temperatures have significantly higher biomass, leaf area, and dark respiration rates than those at Black Rock Forest temperatures. Although photosynthesis on a leaf area basis was comparable in both temperature environments, owing to higher average leaf area, the plants grown at New York City temperatures exhibit higher plant-level photosynthesis. Field measurements showed that calculated plant biomass for plants planted in spring of both 2006 and 2007 are significantly higher at LDEO than in Central Park. However, plants planted in spring, 2006, were significantly higher in Central Park than at LDEO. This study shows that the city's urban environment affects plant function. More research is therefore needed to understand the various factors affecting oak tree growth in these areas.

ORGANEK, Billy

Gas Exchange at Mono Lake

Mono Lake is a saline lake in the eastern end of California. The lake has been used both as a water source for Los Angeles County, and as a testing ground for (non-nuclear) Navy weapons testing. In addition, the lake naturally has unique water chemistry, including a pH of almost 10 and a salinity of 8.1%. The reason that this lake provokes so much interest is because the ratio of ^{14}C to ^{12}C has increased over the past half-century, leading scientists to posit a few possible explanations as to why this would be. The evasion rate for other gases was consistent with empirical data. So the consensus is that there is either something extraordinary about the lake chemistry that causes ^{14}C to behave differently from other isotopes or trace gases, or that there was something in the lake that was providing many times more ^{14}C than would normally be evaded.

The goal of the experiment was to isolate the effect that physical changes had on the evasion rate of CO_2. We built a small- and large-scale housing to hold the water, which was then agitated using either a small bubble tube and air pump or a large fan, respectively. Using N_2O as a control, we measured the evasion rate of N_2O with a gas chromatograph (GC), while Wade McGillis simultaneously measured the CO_2 evasion rates to see if there was a significant change between the evasion rates of the two gases. Ultimately, if the gases exchanged at roughly the expected rates, then we would be able to tentatively discount the physical effects of agitation on gas exchange. However, if N_2O remained within expected bounds, and CO_2 did not, then it would be possible to explain the different evasion rates solely using physical characteristics.

SEIDMAN, Laura

Studies of the Upper Sediment of the Soledad Basin

There were two parts of this project. The first was to develop a method for stabilizing sediment cores collected from the upper 1-2 m of the bottom of the Soledad Basin, a semi-enclosed embayment off the coast of southern Baja California. The sediment has a high water content and is soupy in nature. So several common methods of epoxy impregnation were attempted to find a technique that would effectively harden the core while minimizing distortions. Freeze drying smaller sections of the core and embedding them with a low viscosity epoxy resin under a light vacuum proved to be fairly effective. Ultimately, freshly collected samples will be stabilized in this way and tested for several elements using an X-ray florescence scanner. Cadmium, molybdenum, and silver are sensitive to the El Nino-Southern Oscillation climate phenomenon. So detailed information about their concentrations could be used to generate a record of the past 1,000 years. The second part of the project was to analyze silver in previously collected cores, using the ICP-Mass Spectrometer.

WANG, Steven

The Story Boron Isotopes Reveal About a Bonaire Coral

An ancient Bonaire Coral was examined by a mass spectrometer in order to determine how the climate and pH of Bonaire and the nearby water had changed from the coral's existence (~2,800 years ago) to now. The mass spectrometer helped determine the boron isotopic composition of the coral, which in turn would help to determine the pH level of seawater. In seawater, boron mostly exists as $B(OH)^3$ and $B(OH)^{4-}$, and the distribution of boron species is mainly affected by acidity. Initial analysis of the ratio of $^{18}O/^{16}O$ on the coral showed several periods in

which the ratio increased, suggesting a time when the climate was cooler, drier, or both. Analysis of the $\delta^{11}B$ (the ratio of $^{11}B/^{10}B$) of the different samples from both the ancient and modern coral used for comparison revealed a constant boron isotopic composition. The constant $\delta^{11}B$ revealed that the pH of the ocean did not change over the course of the coral's lifetime. If ocean circulation had changed as a result of a larger contribution of open ocean water to Bonaire, pH should have increased. The high oxygen isotope values in the middle of the coral's growth period could have been caused by either cooler or drier conditions, or both. Further analysis of the $\delta^{11}B$ of the different samples revealed an unexpected relationship: the boron concentration is low where $\delta^{18}O$ is high. This does not support the idea of higher salinity (drier conditions). The next step will be to use cultured corals grown under different temperatures and to measure their boron concentration.

Rabi Scholars (2007-08)

Elizabeth Allocco (CC'11, Neuroscience)
Michael Agne (CC'09, Chemistry)
Samuel Beck (CC'11, Physics)
Erica Berck (CC'11, Neuroscience)
†Corey Bregman (CC'10, Physics)
Jason Byeun (CC'11Mathematics.Economics)
Kevin Chou (CC'10, Applied Mathematics)
Megan Choy (CC'09, Biochemistry)
Jay Dhuldhoya (CC'11, Physics)
Thomas Dumitrescu (CC'08, Physics/Mathematics)
Geoffrey Fudenberg (CC'08, Neuroscience/Physics)
Alexandru Georgescu (CC'11, Physics/Economics-Political Science)
*†Dahlia Goldfeld (CC'08, Chemistry/Physics)
Zachary Gray (CC'11, Physics)
*Lalit Gurnani (CC'11, Biology/Economics)
Stephen Hancock (CC'11, Physics)
†Daniel Hopkins (CC'10, Mathematics)
Maximilian Horlbeck (CC'11, Biochemistry)
John Hwang (CC'08, Biology)
Faisal Khan (CC'09, Physics)
Dmytro Karabash (CC'08, Mathematics)
Michael Kennelly (CC'11, Physics)
Yao Liu (CC'08, Physics)
Yun Liu (CC'08, Physics)
Christopher Lopez (CC'11, Mathematics)
Charles Macanka (CC'08, Computer Science/Mathematics)
Vedant Misra (CC'09, Physics)
Man-Yu Moy (CC'11, Biology)
Chang Hyun Oh (CC'09, Chemistry)
Alexander Perry (CC'11, Mathematics)
*†Oleg Polyakov (CC'08, Physics)
Pawel Przytycki (CC'11, Computer Science)
Mitchell Rubenstein (CC'11, Physics)
Caitlin Schubmehl (CC'10, Chemistry)
Scott Simonovich (CC'08, Chemistry)
Daniel Stewart (CC'11, Physics)
*Olivia Tandon (CC'09, Environmental Biology)
†Xuran Wang (CC'10, Mathematics)
Xuqin David Yang (CC'09, Chemistry)
*Jiang Yio (CC'10, Biology)
Andrew Zhang (CC'11, Mathematics)
Yi Zhang (CC'11, Environmental Science)

FOSTOR Interns (Summer, 2007)

Belinda Archibong (CC'10)
†Melanie Busch (CC'10)
Saireudee Chaturantabut (CC'10)
Allison Lacko (CC'10)
Mia Lewis (CC'10)
Billy Organek (CC'10)
Laura Seidman (CC'10)
†Paige Thompson (CC'10)
†Rachel Vishnepolsky (CC'10)
Steven Wang (CC'10)

*Students unable to participate in this year's symposium owing to other commitments.

†Sophomores, juniors or seniors who did not submit abstracts. Of these, Xuran Wang was excused because he did not undertake summer research in 2007. First-year students involved in summer research were also not required to submit abstracts. Two, Lalit Gurnani and Max Horlbeck, chose to do so.