Proceedings of 2009
Harlem Children Society Workshop & Lecture Series #4
July 28th 2009

On Tuesday, July 28, 2009, the fourth seminar in the Harlem Children Society (HCS) Summer Internship Weekly Series was held in Caspary Auditorium of Rockefeller University. Dr. Sat Bhattacharya opened the day's program with several announcements, particularly focusing on the upcoming HCS Third Annual Science Boat Cruise on August 6th.

Dr. Sat then introduced the first speaker of the day, special guest Dr. Todd R. Disotell, professor of anthropology at New York University. With his areas of interest including physical anthropology, primate evolution, molecular evolution, genetics and mitochondrial DNA, analytical techniques of phylogenetic systematics, and the history of biological anthropology, Prof. Disotell is primarily associated with NYU's Center for the Study of Human Origins. He has been at New York University since 1992, and attained his PhD at Harvard University. Dr. Sat also mentioned that Dr. Disotell has made numerous television appearances in connection with various aspects of his work and has been a distinguished mentor to HCS students for some time.

Dr. Disotell approached the podium to address the students in his talk entitled "Center for the Study of Human Origins." He immediately launched into how we now live in the age of genomics in the wake of the human genome having been sequenced almost 10 years ago. In the last several years, we have turned the tools of genomics - large sequence analysis systems and powerful computer systems - to begin looking at the closest living human relatives, and in connection, study diseases that affect them as well as human populations. These tools also allow us to study how life is working and how it came to be. This, Dr. Disotell claimed, is his central interest.

While lab work gives us tremendous information, Disotell believes that nature is more important to study. As the environment changes, we can study the past. Past planetary warming periods led to the rise of apes and humans. Studying such might help humans adapt to the conditions of global warming.

Prof. Disotell continued, saying we can see changes in life forms that occurred during the last big "warm up." Using the macaque as a control, we can study the chimpanzee genome and make direct comparisons with that of the human. Only by obtaining evolutionary data can we determine the important changes and when they occurred, which, of course, teaches us about ourselves.

"We're in the midst of a massive sequencing effort…. We're sequencing every single lineage of primates as well as other mammals… With this vast amount of data, we need more powerful bioinformatics tools. The field of bioinformatics is *the* growth field in biological and information sciences, so I encourage you to explore it."

Within the coming year, Dr. Disotell claimed that the complete genome of the Neanderthal, the closest human relative, would be sequenced and published. Extinct for 30,000 years, this is a tremendously important for study and comparison to humans.

He continued, saying that as a result of tremendous competition, there is a widespread effort to get the cost of sequencing down to $1,000. Once this happens, Disotell claimed, it would become affordable in modern medicine to tailor health care individually based upon such. This is the future of healthcare.

For his own research, Disotell collects and studies primates by examining DNA, Dr. Disotell spoke about how it is obtained most frequently through animal feces. He explained that when animals defecate, they slough a number of cells containing DNA. By studying fecal matter, the animals are not disturbed, and it is much easier and safer to gather. Since most primates are endangered species and on the verge of extinction this becomes more important. When animals become used to humans, it can make them less wary of such potential dangers as hunters. In fact, Disotell continued, his colleagues try to keep their distance.

Further, he continued, examining fecal matter gives us information on diet, and is useful in behavioral and relationship studies. "We can track and follow animals through 10s of kilometers of rainforests and other areas of vegetation based on the type of DNA found in waste. Collecting nightly feces in the nest allows us to determine what is going on with the animals without humans ever having to see them. Further, we are also obtain mitochondrial DNA."

He revisited the study of the complete Neanderthal sequencing earlier mentioned, and how it was made possible through studying saliva, bone, tissue, etc. In his work, Dr. Disotell emphasized that he uses all the techniques that a medical examiner would use.

Though most of the work in Dr. Disotell's lab involves primates, it also involves exploring different aspects of the genome, even ancient dead viruses. Though dead, these viruses have crept into human DNA. There are jumping genes and repetitive DNA, and his lab can look down to all the base levels.

The professor delved into how lab-work has changed and become dramatically easier. For example, in 1989, one had to manually sequence DNA using radioactive substances to count results. By 1992, in his PhD thesis, Dr. Disotell had painstakingly collected hundreds of DNA samples from several hundred species of animals, but now this process is much easier. A, C, G, T's had to be individually examined. Nowadays, the lab uses microscopic capillaries, which are then shot through by lasers in order to generate thousands of bases of DNA within an hour or two.

Disotell pointed to one primary genome of focus in his lab: mitochondrial DNA. At 16.5 million bases long, it is maternally inherited, easy to work on, and a clean evolutionary history is easily attained. One of his lab's projects is to develop computer programs to analyze mitochondrial DNA.

He then stated that all efforts would be wasted without incredibly powerful computer algorithms and approaches. This is perfect for people who don't perform lab work well since it involves computers. Dr. Disotell develops new algorithms for analyzing evolutionary data**.**

The professor then took a moment to again encourage students to consider entering this field and to analyze data. He explained that all DNA sequences are publicly available and can be analyzed in public databases. This summer, his students with programming experience are learning to write programs, analyze, and gather data from these public databases as part of the "open source software movement." Disotell underscored how making graphical representations is a very important part of this process.

He then turned to some specific projects his lab has been recently pursuing, including trying to answer questions about human and primate history. One of his Post docs has been studying populations in Southeast Asia by looking at genotypes and thereby piecing history together.

"Using molecular DNA data, we can infer when different lineages of organisms split from one another because fossils are not always available." Using 'the molecular clock,' his lab has been surprisingly able to determine that human ancestors actually came from Asia rather than Africa. The fossil and geological records support this. Disotell went into how human migration had been traced to Asia roughly 10 million years ago, and then had migrated to Africa at a time when the two continents had been physically connected. Fossils found in Turkey and Greece are similar to those of Africa and provide the evidence of this migration. This would suggest that the orangutan is a distant relative of the human.

In other project, Disotell has studied primates from Central and South American and can answer general questions about them based on molecular data. They had come to the area some 30 million years ago and developed into a number of species. Then, some 20 million years ago, all species became extinct except for one type. Through the lab's studies of molecular data, Disotell and colleagues are working on arriving at whether modern monkeys come from the 30 million year old type or the later surviving type.

Dr. Disotell turned to another facet, displaying a photo of children in Congo selling monkey meat for human consumption. He was illustrating SIV (simian immuno-deficiency virus), similar to human HIV, and how it is spread through eating this type of meat. By examining the molecules of the disease, and based on previous studies of old world monkeys, Disotell's lab can see the exchange of SIV and how infection spreads.

Almost all of the primate species, he continued, that carry SIV have built natural immunity over the ages. His lab has made great progress in identifying genes that seem to confer certain resistance, and may potentially be used by biomedical researchers. The "new news" is that a subspecies of chimpanzees in Gambia are becoming newly infected and are dying from SIV. Prof. Disotell's lab is studying what the changes associated with the disease are to compare to those with subspecies with immunity. Similarly, Disotell's lab is also studying malaria by looking at receptor molecules and proteins to determine

changes and apply them to biomedical research to cure it.

Disotell's lab also studies conservation genetics to determine chances of survival of a given species. In connection, he spoke of his lab's forensic genotyping of Diane Fosse's gorillas and trying to determine their identities based on available detailed behavior records. They are trying to match to samples brought to Europe in the 1960s and 1970s. "It is a real forensic case, but it happens to be on gorillas."

Disotell also talked about having fun with science. He enjoys the challenge of identifying monsters such as Bigfoot, Yeti, Sasquatch, etc. So far, he has found but humans, bears, synthetic hair, coyotes, and other common animals in over a dozen recorded cases of "monsters." However, Disotell believes in doing this research to debunk crazy theories with DNA testing.

Prof. Disotell closed by underscoring the importance of studying evolution. He said, "I like to think of evolution as the grandest lab around. If only we can read its notebooks, will we really understand who we are (sic), where we came from, and perhaps where we're going, and help ameliorate the conditions we suffer from." The professor then engaged students in a lively question and answer period.

Dr. Sat approached the podium and addressed the students briefly before introducing Mai Abdelal, HCS Class of 2009, and a student at Benjamin N. Cardozo High School. Mai presented her research under the mentorship of Prof. Disotell and Christina Bergey at NYU entitled "Analyzing Mitochondrial DNA in New World Monkeys."

Mai's focus work was on bioinformatics, new world monkeys, Python Script, and the human genome. Her purpose was to find the region of mitochondrial DNA with the most variation, which has multiple uses in science. She also wanted to learn how to use Python Script to create programs that compare base pairs and add up the differences. The student stated that at the end of the summer, she and the other four HCS interns would be integrating their work into a complete research project.

She then furnished some background information on her research. Mai defined bioinformatics as the use of computer science, mathematics, and information theory to model and analyze biological systems, especially systems involving genetic material. While illustrating with a slide depicting primates, she spoke about how new world monkeys are indigenous to the tropical forest environments of southern Mexico, Central, and South America. As she showed a slide with a diagram depicting the human genome, nuclear genome, and mitochondrial genome, she explained each of them.

Mai then defined mitochondrial DNA. Mitochondria are structures within cells that convert the energy from food into a form that cells can use. Although most DNA is packaged in chromosomes within the nucleus, mitochondria also have a small amount of their own DNA. This genetic material is known as mitochondrial DNA or mtDNA. She then displayed a molecular diagram that illustrated such.

The student defined Python Script as a dynamic object-oriented programming language that can be used for many kinds of software development. Mai then concluded by showing slides of sequenced mitochondrial DNA comparisons and primate families.

Dr. Sat then returned to the podium to present the HCS Presidential Science and Society award to Prof. Disotell. Afterwards, Dr. Sat spoke about various science fields, and echoed Dr. Disotell's words how one might begin in one scientific discipline, but end up in another. He next introduced student speakers Katherine Chan and John Liu, two students who had participated in the SMART/REIS program at University of New Hampshire in summer 2008.

Katherine Chan, a student at Legacy School for Integrated Studies, and Jonathan Liu, a student at Queens High School for Science at York College, both HCS Class of 2008, spoke about their research entitled, "Sexual and Asexual Reproduction and Cloning of Plants." In this project, their objective had been to learn the techniques of cloning as well as to study the regulation of development in plants by plant hormones, specifically the use of auxins and cytokinins.

The students' background information provided basics on sexual and asexual reproduction, i.e., reproduction in the human and animal world vs. plant reproduction. The students defined sexual reproduction as two cellular events, meiosis and fertilization, in which the number of the chromosomes is reduced to half of that in a typical body cell, and are referred to as somatic cells. Meiosis is the process that divides the chromosomes and fertilization is what restores it back to its normal number of chromosomes. Chromosomes are capable of being restored with the help of fusion of gametes, the cells that fuse together to reproduce sexually.

They defined asexual reproduction, aka cloning, as the process by which an organism is developed directly from somatic cells, and does not involve meiosis or fertilization. An individual species receives its chromosomes from a single organism, causing it to be identical to the organism, in this case a plant. In further discussion of cloning, the students remarked that plant cloning is much easier to achieve than animal cloning, as it need only involve a single cell.

In their experiment, the students had utilized plant tissue culture medium, sterile Petri dishes, plant materials (leaves and roots), forceps, scalpels, saran wrap, and laminar flow hoods. They had placed a plant sample and placed it onto an agar plate, to which the hormones auxins (roots) and cytokinins (shoots) had been added.

The sample had then been exposed to sunlight to facilitate the photosynthesis process, and as time elapsed, the samples were held in controlled environment. Though they had not had enough time to complete their experiment, they spoke about the two types of results that they might have expected to achieve. If the experiment had worked out positively, then the plant would grow roots and leaves attached to one other as an actual plant. If, on the other hand, the experiment had been flawed, then the plant would grow tumors or would not grow at all. As for the future, the students expressed their desire to continue their plant-cloning project through to completion. Though they have an idea about the appearance of their cloned plants, they had only been able to observe a

week of growth because of time constraints.

Dr. Sat critiqued the students' presentation, and gave them helpful suggestions. He then posed questions to the students about the difference between nuclear and mitochondrial DNA. He explained that since mitochondrial DNA is passed maternally, evolution could be studied. Dr. Sat then introduced the next student speakers.

Givi Basishvili, HCS Class of 2009 and a student at Bard High School Early College, along with Xavier Marrero, HCS Class of 2005, and a student at Frederick Douglass Academy next presented their research entitled "Micro-Bubbles," which they are doing under the mentorship of Prof. Mark Borden, Ed Swanson, and Nathan Lee in the Department of Chemical Engineering at Columbia University.

The students first defined micro-bubbles as being tiny bubbles (>10μm; 0.000001meters) that can contain oxygen, genetic information (such as DNA), or drugs. They are used for medical purposes to deliver chemicals to specific areas. They are then targeted and popped by ultrasound to deliver the specific drugs in the treatment of cancer, lung failure and other disorders.

The students then discussed oxygen bubbles as being useful in keeping patients with lung failure alive. By injection directly into the blood, oxygen is acquired by the red blood cells and hemoglobin.

As for bubble chemistry, the components are lipids (to maintain stability), oxygen, water and intermolecular forces. The engineering process involves production on a microscopic scale. A tank is filled with lipid and oxygen, and sound waves are applied, thus creating oxygen bubbles.

Givi's and Xavier's research involved creating stable bubbles. They wanted to determine the best storage conditions and bubble properties. Most importantly, they wanted to test the engineered bubbles in vivo (living organisms).

Givi then discussed stability tests and problems they have encountered. Their micro-bubbles have lasted but for 3-5 days so they would like to make them as stable as possible. They have performed two different experiments to test whether leaving the micro-bubbles in refrigeration is a more stable environment than in room temperature Though they found that the gas density decreased in both experiments, it did more readily at room temperature Therefore, they concluded that the micro-bubbles left in the refrigerator were far more stable that those left at room temperature.

The students have also explored rotation in connection with storage. Their hypothesis was that rotation would prevent bubble coalescence. After testing, they determined that rotation created higher kinetic energy, thus more instability. They also found that collision with the wall also caused damage.

As for the future, the students would like to test different lipid formulas. They would also like to vary the engineering techniques used to create bubbles and determine their elasticity. Givi and Xavier then concluded their presentation with a short question

and answer period.

Dr. Sat again returned to the podium to introduce the next student presentation, ”Non-Apoptotic Linker Cell Death in C. elegans.” The student, Hafsa Yucel, HCS Class of 2008 and a student at Brooklyn Amity High School, is doing her research under the mentorship of Elyse Blum at Rockefeller University in the Department of Developmental Genetics.

Hafsa began by first discussing the importance of studying cell death because it is an important step in the development of an organism. By understanding it, we can better understand and develop cures for neurodegenerative diseases. In the case of neurodegenerative diseases, cells die “when we don’t want them to die, while cancer and tumor cells continually divide when we want them to die.”

She continued, saying that cell death during animal development is important in sculpting the organism, deleting structures, adjusting cell numbers, and eliminating dangerous or injured cells. Programmed cell death (PCD) is involved in forming structures (digits of the hand), deleting structures (nearly all of an insect’s larval components), controlling cell numbers (e.g., the nervous system), and eliminating cells such as those that harbor mutations (important to the human immune system).

It has been discovered that cell death in *C. elegans* is similar to that in other organisms. *C. elegans,* a nematode (roundworm) is commonly used in many areas of biology as a model organism. Hafsa pointed out that we know everything about the worm, including cell lineage, which means that we know every cell division and death during the process of a single cell turning into an adult. The genes that mediate and control programmed cell death (PCD) in *C. elegans*: *ced-3*, *ced-4*, and *ced-9* have similar roles in other organisms. Therefore, understanding the causes and the process of cell death in *C. elegans* is very helpful in understanding cell death in more complex organisms, such as humans. The caspase-based cell death (apoptosis) is present in humans and other organisms.

Hafsa then delved into the definition and role of the linker cell that leads and shapes the gonad in *C. elegans*. (The gonad is the germ line and egg-laying apparatus of the worm.)

The purpose of the linker cell is to shape the gonad. At the end of the tail where the gonad ends, the linker cell is supposed to die. If it doesn’t die, the gonad becomes blocked and the worm becomes infertile.

The student then displayed a table illustrating the wild type (the “normal” animal) in which the linker cell is supposed to die. Because there is 0% linker cell survival in the wild type *C. elegans*, none of the genes that maintain apoptosis affects linker cell death. We know that in theory, the linker cell is non-apoptotic because it uses a wholly different cell-death pathway. Hafsa presented a slide depicting the apoptotic corpse and linker cell corpse, which appeared very different. It was clear that the shapes were very different. She claimed that we know the genes that control apoptotic death and we want to know and understand the genes that control non-apoptotic death.

Therefore, Hafsa's objective is to find new genes that control linker cell death. She also wants to test genes to see if they activate *sek-1* or are activated by *sek-1*. Hafsa's mentor has already identified some genes that control linker cell death. In connection, there are two hypotheses: 1) *sek-1* works alone to promote linker cell death and 2) *sek-1* works with other proteins in the MAP Kinase pathway. Hafsa is testing new genes related to *sek-1* in the MAP Kinase pathway.

She then illustrated *sek-1* functions in the MAP Kinase pathway in *C. elegans.* Hafsa further explained that MAP is the mitogen-activated protein, kinases are a transfer phosphate group, and that a mitogen controls mitosis. *Pmk-1* is a special protein that signals many other proteins to be made so an animal can fight infections. AWC is the nerve cell. This group is used in two different cells with two different functions. First, it triggers immune response. Second, it makes a protein that controls the expression of receptors in the cell. The third kinase hasn't been identified.

Hafsa's mentor wanted to know if *nsy-1* or *pmk-1* affect linker cell death. It has been determined that these proteins do not have an effect, so Hafsa and her mentor want to determine if *sek-1* either works alone or works with similar proteins, and they are testing this premise. Since there are many map kinase pathways, they are testing whether there is an effect on linker cell death or not.

The student's methodology has involved developing a cross strategy to test different genes, scoring (counting) new strains to determine whether there is a linker cell death defect, and visualization of the linker cell through GFP (green fluorescent protein, which glows under a special microscope and is expressed in the linker cell). Hafsa's work has largely involved crossing worms to obtain a new strain of them.

Mtk-1 was one of the genes that Hafsa wanted to test, so she set about tracking it. Since *dpy-5* (used to track *mtk-1*) and *mtk-1* are both found in chromosome 1, this was not too difficult. The student displayed a slide showing both wild type and "dumpy looking worms" (*C. elegans).*

Hafsa's cross strategy for *mtk-1* was to cross *qIs56 him-5* males with *dpy-5* hermaphrodites. Then, she would select 6 GFP+ non-dumpy males and cross the GFP positive non–dumpy males with *mtk-1* hermaphrodites. Following, Hafsa would select 18 GFP+ non-dumpy hermaphrodites and isolate them.

She defined *qIs56* as the GFP gene. Hafsa and her mentor have found that with *him-5*, there is a high incidence of male population. Normally the population would be about 2% male, but with the addition of *qIs56*, Hafsa found a much greater proportion (@ 30%). The goal was to cross the males, hence this gene was added.

Next, Hafsa scored the plates for the absence of dumpies. On the plates with dumpies, she would select 32 non-dumpy GFP+ hermaphrodites to individual plates, and isolate them. The goal was to isolate two populations: 100% GFP+ and 100% non-dumpy.

Hafsa turned to results, stating that she is the last step of the cross strategy right now. So far, the cross has been successful with *mtk-1*. The student and her mentor are going to make a new cross with *pek-1*. Once the cross is completed, she will score for linker cell survival. Hafsa has selected the 32 worms and is now waiting for them to grow in order to assess success. She has already begun the *pek-1* cross, which is a completely different strategy.

As for her future work, Hafsa claimed that she and her mentor would be completing the cross with *mtk-1*, and would then look at the results. She plans to finish the new cross with *pek-1* and *qIs56 him-5* to test *pek-1* gene. Hafsa concluded by saying that she would like to test more MAP kinases, which transfer phosphate groups.

Dr. Sat returned to the podium and gave a brief discussion on scholarships, and HCS's role in nominating its students. Dr. Sat was setting the stage for the next student presentation by Roslyn Joinvil, HCS Class of 2006, and a student at New York City College, as well as a Gates Millennium Scholar recipient.

In a presentation entitled "Gates Millennium Scholars – Leaders for America's Future, " Roslyn first introduced the Gates Millennium Scholars Program (GMS) by saying that it is funded by a $1 billion grant from the Bill & Melinda Gates Foundation and was established in 1999. The goal of GMS is to promote academic excellence and to provide an opportunity for outstanding students with significant financial need to reach their fullest potential. The United Negro College Fund (UNCF), the administrator of the GMS initiative, partners with the American Indian Graduate, Center Scholars, Asian & Pacific Islander, and the American Scholarship Fund in the venture.

Roslyn then discussed the value of the GMS Scholarship Award. It provides support for the cost of education by covering unmet need and self-help; renewable awards for Gates Scholars maintaining satisfactory academic progress; graduate school fellowships for continuing Gates Scholars in the areas of computer science, education, engineering, library science, mathematics, public health and the sciences; and leadership development programs with distinctive personal, academic and professional growth opportunities.

Some of the benefits of the Gates Millennium Scholars Scholarship include: the GMS Ambassador Program, Leadership Development conferences, revised scholarship awards (when necessary), deferment options, academic empowerment services, mentoring, and GMS Circles.

The student underscored that the GMS program is more than a scholarship. The program offers Gates Millennium Scholars Academic Empowerment (ACE) services to encourage academic excellence, mentoring services for academic and personal development; and an online resource center that provides internship, fellowship and scholarship information.

The student then delved into eligibility criteria. Students must be African-American, American Indian/Alaska Native, Asian Pacific Islander American, and Hispanic American. They must be citizens, legal permanent residents or nationals of the

United States with a cumulative GPA of 3.3 on a 4.0 scale (un-weighted) at the time of nomination or must have earned a GED. Applicants must be degree-seeking freshman who will be entering an accredited college or university as full-time students with demonstrated leadership abilities via participation in community service, extracurricular or other activities. Further, applicants must meet the federal Pell Grant eligibility criteria.

Roslyn discussed the nomination process as first requiring an educator who is familiar with the student's academic background to nominate them and complete the Nominator Form. A community member or individual familiar with the student's community service and leadership activities must complete the Recommender Form and the applicant must complete a comprehensive Nominee Personal Information Form. Roslyn then detailed the contents of the complete student nomination packet. She also presented some of the questions that appear on the student form.

The student then turned to the scholarship timeline, and detailed submission schedule according to such. Students who apply for the GMS scholarship are notified of their status (Non-Select or Finalist), and then finalist application information is verified including GPA, citizenship status, and federal Pell grant eligibility. The 1,000 selected Gates Scholars are then notified by the organization.

Roslyn detailed the support resources associated with the GMS network of online communities *(http://www.gmsp.org)*. As a recipient of the scholarship, she then provided her own application tips. Roslyn concluded by describing life as a GMS Scholar. It offers financial stability, fostering leadership skills such as GMS Ambassador, opportunities to attend Leadership Conferences, the GMS Circle, endless networking opportunities and building life-long friendships.

The seminar then broke for lunch. The proceedings reconvened beginning with HCS staffer Ana Catalina Santos Ramos's presentation, "The Different Perceptions of Happiness in "Snow" by Orhan Pamuk.

Before Ms. Santos began her discussion, she presented a short film clip from a BBC TV documentary focusing on neuroscience and the measurement of happiness and pleasure through brain imaging. Following the introductory video, Ms. Santos introduced the book, saying it had received the 2006 Nobel Prize for Literature. Published in 2002, the novel is ".., a tale of disparate yearnings – for love, art, power, and God – set in a remote Turkish town, where stirrings of political Islamism threaten to unravel the secular order.

"Following years of political exile in Western Europe, Ka, a middle-aged poet, returns to Istanbul to attend his mother's funeral. Only partly recognizing this place of his cultured, middle-class youth, he is even more disoriented by news of strange events in the wider country: a wave of suicides among girls forbidden to wear their head scarves at school. An apparent thaw of his writer's curiosity – a frozen sea these many years – leads him to Kars, a far-off town near the Russian border and the epicenter of the suicides. No sooner has he arrived, however, than we discover that Ka's motivations are not purely journalistic; for in Kars, once a province of Ottoman and then Russian glory, now a cultural gray-zone of poverty and paralysis, there is also Ipek, a radiant friend of

Ka's youth, lately divorced, whom he has never forgotten. As a snowstorm, the fiercest in memory, descends on the town and seals it off from the modern, westernized world that has always been Ka's frame of reference, he finds himself drawn in unexpected directions: not only headlong toward the unknowable Ipek and the desperate hope for love – or at least a wife – that she embodies, but also into the maelstrom of a military coup staged to restrain the local Islamist radicals, and even toward God, whose existence Ka has never before allowed himself to contemplate. In this surreal confluence of emotion and spectacle, Ka begins to tap his dormant creative powers, producing poem after poem in untimely, irresistible bursts of inspiration. But not until the snows have melted and the political violence has run its bloody course will Ka discover the fate of his bid to seize a last chance for happiness. Blending profound sympathy and mischievous wit, Snow illuminates the contradictions gripping the individual and collective heart in many parts of the Muslim world. But even more, by its narrative brilliance and comprehension of the needs and duties." ("Snow" – jacket text)

Ms. Santos' analysis of the notion of happiness within the context of the novel had led her to explore the scientific and classical perspectives and definitions, which she shared with the audience. In her research, Ms. Santos had also surveyed HCS students for their definitions of happiness, and shared some of those responses. She then delved into novel's main characters and a discussion of the notion of happiness along that perspective.

Ms. Santos then turned to science and quantifying/measuring happiness. According to Dr. Martin Seligman, Director of the University of Pennsylvania Positive Psychology Center and Founder of Positive Psychology, "authentic happiness" involves positive emotions, strength-based character, and healthy institutions.

Ms. Santos then spotlighted two other viewpoints: those of Sonja Lyubomirsky, Professor of Psychology at University of California, Riverside and author of "The How of Happiness: A Scientific Approach to Getting the Life You Want, " and Claudia Wallis, author of a Time magazine article entitled, "The New Science of Happiness." She shared responses to a survey that was highlighted in that article.

Before she concluded, Ms. Santos shared Prof. Lyubomirsky's findings that the characteristics/qualities of the happiest people include being more grateful, more forgiving, less likely to compare themselves with others, less likely to dwell on little things, more likely to live in the present moment, and more likely to set goals and seek to meet them. Ms. Santos concluded by saying that perspective is very important in the question of happiness, and used the half-empty/half-full water glass illustration of that idea.

Dr. Sat returned to the podium and in connection with Ms. Santos' presentation on happiness, discussed clinical depression and drug therapy. He then introduced the next student speakers on the program.

Basiru-Lee-Leigh, HCS Class of 2006, and a student at Bronx High School of Medical Science, and Nicholas Gonzalez, HCS Class of 2009, and a sophomore at Binghamton University, under the mentorship of Dr. Karen Bell at Columbia University

Medical Center, presented "Fronto-temporal Dementia (FTD)".

The students first defined FTD as a subtype of Fronto-temporal Lobar Degeneration, a degenerative condition of the anterior part of the brain. FTD involves a disturbance of behavior and personality such that patients suffer a change in their character. The disorder differs from other degenerative conditions like Alzheimer's and CJD, and is marked by dramatic changes in personality, behavior and some thought processes. The disease is marked by an insidious onset, slow progression, and deficits in behavior, judgment, language, and social conduct.

A variety of mutations on several different genes have been linked to specific subtypes of FTD, but more than half of those who develop it have no family history of dementia. In some cases, the affected parts of the brain contain microscopic Pick bodies — abnormal protein-filled structures that develop within brain cells.

Basiru and Nicholas showed diagrams of the brain, affected and unaffected with FTD. They discussed the symptoms as including: impairment in social skill, change in activity level, decreased judgment, changes in personal habits, alterations in personality and mood, akinesia, and failure or inability to make motor responses to verbal commands.

As for the statistics on the disease, seven million Americans may be affected with a form of dementia. FTD may account for 2-5% (or 140,000–350,000) of those cases of dementia. It occurs predominantly between ages 40-65 and is an equal risk for both men and women.

The students displayed a pie chart reflecting the various types of dementia, and made comparisons between several varieties. In a side-by-side comparison, both FTD and Alzheimer Disease (AD) were characterized by atrophy of the brain, and a gradual, progressive loss of brain function. FTD is distinguished by cerebral atrophy in the frontal and anterior temporal lobes of the brain. Patients exhibit memory disturbances, remain oriented to time and place and recall information about the present and past. Even in late stages of the disease, patients retain visuo-spatial orientation, and they negotiate and locate their surroundings accurately. Life expectancy is slightly longer for FTD as it has no amyloid plaques or tau tangles that infect the brain.

In contrast, Alzheimer's Disease (AD) affects the hippocampal, posterior temporal and parietal regions of the brain. Patients experience severe memory loss and have an inability to learn new information. AD's onset usually occurs at about age 65, and is characterized by loss of nerve cells, with presence of tau tangles and amyloid plaques.
There are three pathological subtypes of FTD. The students first discussed the subtype, bvFTD (Behavioral Variant FTD), also referred to as *Pick's Disease*. Patients with Pick's Disease have an abnormal protein, "pick bodies," inside nerve cells in the damaged areas of the brain. BvFTD is characterized by early and progressive changes in personality, emotional blunting and/or loss of empathy. Language impairment may also occur, but is less prominent and would appear as a word-finding problem. It is the third most common form of dementia, Alzheimer's being the first, and is most commonly found in people of Scandinavian descent in connection with a specific chromosome. The patient's symptoms

typically include hyperorality, stereotyped and/or repetitive speech, hyper-sexuality, impulsiveness, apathy, and mood changes.

The students then discussed Semantic Dementia (SD), which accounts for about 20% of all FTD cases. Difficulty with language is the key malfunction experienced by SD patients. Memory function, however, tends to stay intact, so patients are fully aware of time and place. The sign of onset involves early loss of word and object knowledge. Further, SD patients eventually develop bvFTD behaviors such as apathy and loss of empathy.

Basiru and Nicholas then turned to Progressive Nonfluent Aphasia (PNFA), which accounts for 20% of all cases of FTD. Unlike SD, people with PNFA have problems associated with pronunciation rather than word meaning/loss. Signs of PNFA include slurred speech, breathiness, deficits in comprehension of syntactically complex sentences, sound distortions or hesitancies in initiation, and grammatical deficits in language production.

Currently, there is no specific treatment or cure for FTD, but there are treatments for symptomatic relief. These drug therapies include antidepressants, antipsychotics, anticonvulsants, and Medroxyprogestrone. There are clinical trials being conducted to collect safety and efficacy data for new drugs and devices. Depending on the kind of product and the phase of its development, investigators register patients in small pilot studies, which are followed by larger-scale studies in patients that often compare the new product with the presently prescribed treatment. The safety and efficacy data are collected, and the number of patients is typically increased.

The students drew to a close, saying that clinical trials of Memantine are being conducted for FTD treatment. The students' mentor is involved in the testing of this drug to determine whether it is effective in slowing the rate of behavioral decline in FTD. The study will also assess the safety and tolerability of long-term treatment with Memantine in patients with FTD or SD, its efficacy in slowing the rate of cognitive decline FTD, and evaluate whether it delays or decreases the emergence of Parkinsonism in FTD.

Dr. Sat returned to the podium to introduce the next guest speaker of the day, Dr. Gil Zussman, of the Department of Electrical Engineering at Columbia University. "Gil Zussman received the B.Sc. degree in Industrial Engineering and Management and the B.A. degree in Economics (both *summa cum laude*) from the Technion – Israel Institute of Technology in 1995. He received the M.Sc. degree (*summa cum laude*) in Operations Research from Tel-Aviv University in 1999 and the Ph.D. degree in Electrical Engineering from the Technion – Israel Institute of Technology in 2004. Between 1995 and 1998, he served as an engineer in the Israel Defense Forces. Between 2004 and 2007 he was a Postdoctoral Associate in LIDS and CNRG at MIT. During 2007-8 he was a Research Fellow in the Department of Electrical Engineering at the Technion.

Gil is an Assistant Professor in the Department of Electrical Engineering at Columbia University. His current research interests are in the area of computer networks. In particular, he is interested in the design and performance evaluation of protocols for wireless networks including ad hoc, mesh, sensor, cognitive radio, and personal area

networks. He has been an Area Editor of Ad Hoc Networks, the TPC chair of Med-Hoc-Net'09 and the WCNC'09 MAC Track, and a member of a number of TPCs (including the INFOCOM, MobiHoc, and MobiCom committees).

Dr. Zussman received the Knesset (Israeli Parliament) Award for distinguished students, the Marie Curie Outgoing International Fellowship, and the Fulbright Fellowship. He is also a recipient of the Best Student Paper Award at the IFIP-TC6 Networking 2002 conference, the IEEE Communications Magazine Best Paper Award at the OPNETWORK 2002 conference, and the Best Paper Award at the ACM SIGMETRICS / IFIP Performance'06 conference. In 2009 he received the DTRA Young Investigator Award and was a member of a group that won the 1st place in the Vodafone Foundation Wireless Innovation Project competition." *http://www.ee.columbia.edu/~zussman/bio.html*

Dr. Zussman presented his talk on "Wireless Networks – Design Considerations, Algorithms, and Research Problems." He opened his discussion by first describing existing networking technologies in three categories: wireless metropolitan area network (long range), wireless local networks, and wireless personal area network (short range, low data rate network, including Bluetooth, WiMedia). Dr. Zussman then defined the Medium Access Control (MAC) and the physical layers. He added that these wireless networks are usually ad-hoc networks with very special characteristics.

Prof. Zussman then outlined his talk. He planned to begin with discussing wireless networking standards, including WiFi, Bluetooth, and WiMedia. Next, he would approach wireless networks and applications, design considerations, protocols and research problems.

He then turned to defining Medium Access Control (MAC). Nodes are scattered in a geographic area, and we must somehow coordinate the access to channels, with considerations of transmission time, power, rate, etc. Centralized MAC is managed by an Access Point/Base Station with someone in charge. Distributed MAC is guaranteed and is random access (Aloha, CSMA, Ethernet). The technology design requirements include throughput, quality of service, fairness, and energy efficiency.

Dr. Zussman then turned to WiFi, and the standards set for wireless local area networks (WLANs). The MAC and physical layer must be defined. The most common is 802.11g with maximum data rate of 54 Mb/s and a frequency band of 2.4 Ghz. There are other variations of 802.11g, including 801.11a,b, e, n with different bands, physical layers, data rates, QoS, etc.

The professor then compared two different modes: ad-hoc and infrastructure modes. With the ad-hoc mode, stations communicate with one another and are not connected to a larger network. With the infrastructure mode (which is usually used in the home), an access point connects stations to a wired network. Overlapping access points are connected to one another, and stations are allowed to roam between access points.

How does it work? The MAC is CSMA/CA, i.e., Carrier Sense Multiple Access/ Collision Avoidance. With CSMA MAC, the station wishing to transmit a data packet

senses the medium (listens to the channel). If it is idle for a given period, it transmits. In either CSMA/CA, an ACK (acknowledgement) packet is sent by the receiving station, and collision is assumed if the sending station doesn't receive ACK. The data is then retransmitted after a random amount of time. In the case of CA MAC, a station that heard the data or the ACK, knows the time remaining until the medium will become available and will not try to transmit during that time.

Collisions can occur because of a hidden node problem - a node that a station does not hear but can interfere with its transmissions. The problem can be solved using Request to Send (RTS) and Clear to Send (CTS). Neighboring nodes should understand from these packets when the medium will become available.

If a channel is heard to be busy, this is called the contention window. In this case, a station that sensed the medium as busy or did not receive an ACK will try to retransmit. The retransmission time is uniformly distributed in the contention window, and the window is doubled every time there is a need to retransmit.

Dr. Zussman then turned to discussing the multihop 802.11 MAC. It has no predefined topology (depends on transmission powers), no "links" and "neighbors," and is not really "disks." He then briefly discussed the Bluetooth MAC with a frequency hop / time division duplex scheme. Its frequency band is 2.4 GHz ISM band at 1,600 slots per second. Bluetooth operates with a piconet - a master and up to 7 slaves that share a common hopping pattern.

Another technology still in development, Zussman continued, is WiMedia (802.15.3) MAC that features a Piconet Coordinator (PNC) which allocates resources to devices (DEVs) that can talk to each other. Timing is based on a super frame. The first period is the contention access Period – CSMA/CA. Both management contention time and contention time allocation are governed by the Piconet Coordinator.

With multihop topology, several piconets may coexist in the same coverage area with minimal interference. A unit can be a Piconet Coordinator, device or bridge. There are links and neighbors.

Dr. Zussman then began his discussion of wireless networks and applications. He first delved into mobile ad-hoc networks (MANETs). They involve tens to hundreds of mobile nodes (PDAs, Laptops, etc.) and do not require fixed infrastructure. Easily deployed, their main applications are the military, disaster recovery, traffic and public safety.

He then discussed wireless sensor networks (WSNs), which involve hundreds to thousands of nodes. Generally stationary (at random locations), their applications include the military, weather/earthquake/fire monitoring, agriculture, building control, and Mars exploration. With this technology, energy conservation is critical. Depleted batteries will not be replaced as the sensors become useless. Hence, energy efficient algorithms are required to maximize the lifetime of the application.

Next, Prof. Zussman spoke about wireless mesh networks (WMNs). Providing a

solution for last-mile access, mesh routers form the backbone, are rarely mobile, have no energy constraints and have multiple interfaces operating in orthogonal channels. There exist multi-radio multi-channel wireless mesh networks. Several networks are currently deployed in Cambridge, Las Vegas, and Taipei.

Dr. Zussman then addressed design considerations. He first stated that the "classical" networking models and protocols do not apply to wireless networks due to factors such as interference, energy constraints, mobility, frequent topology changes, and absence of central authority. He continued, elaborating on each of these factors.

Interference is due to the broadcast nature of the channel. Wireless channels are prone to errors. Interference can also be caused by packets from the same system or by other systems (e.g., Bluetooth ↔ WLAN). A transmission is successful if other transmissions do not take place at the same time, depending on signal-to-noise ratio and power, distance, etc.

Another issue is energy consideration. Energy conservation, critical in sensor networks and important in mobile ad-hoc networks, can be conserved at various layers. In design consideration, one must decide what is most important – to save energy (via shortest path) or maximize lifetime. Power control is also important to avoid interference and determine topology.

With respect to mobility, in MANETs and VANETs nodes move around, thus resulting in topology changes. Different mobility characteristics such as predictability and speed must be considered. Frequent topology changes are due to mobility, battery depletion, changing channel status (interference), changing transmission energy, and changing transmission frequency/channel. Unlike in wireline networks there are no predetermined links, neighbors, or topologies. With routing, links are set up and frequently fail.

The final consideration involves distributed operation. There is no central authority responsible for networks management. Nodes may appear/disappear frequently, have no global knowledge, and make local decisions and exchange control messages only with their neighbors. Distributed algorithms usually achieve suboptimal solutions, though there are tradeoffs between complexity and performance.

Another concern is cross layer design. Energy conservation and power control affect the design of MAC algorithms, routing algorithms and topology construction algorithms. Interference at the physical layer affects the performance of TCP at the transport layer. TCP may enter congestion avoidance due to wireless transmission failure.

Dr. Zussman turned to network protocol examples. The required protocols for wireless networks have to take into account the special design considerations. Some of the design considerations have been taken into account in the current MAC protocols, including distributed operation, energy saving mode and RTS/CTS. In general, designing wireless protocols is a difficult problem as there are no easy solutions that fit all applications/networks.

MANET involves unicast routing protocols. Many of these protocols have been proposed, some of which have been invented specifically for MANET. Others are adapted from previously proposed protocols for wired networks, however no single protocol works well in all environments.

Routing protocols are either proactive, reactive or hybrid. Proactive protocols determine routes independent of traffic pattern. Traditional link-state and distance-vector routing protocols are proactive. Reactive protocols maintain routes only if needed.

Dr. Zussman then provided an example of routing protocol: AODV. Route requests (RREQ) are forwarded in order to find the destination. When a node re-broadcasts a route request, it sets up a reverse path pointing towards the source. AODV assumes symmetric (bi-directional) links. When the intended destination receives a route request, it replies by sending a route reply, which then travels along the reverse path set-up when the route request is forwarded. So, with AODV, nodes maintain routing tables containing entries only for routes that are in active use. At most one next-hop per destination is maintained at each node. Unused routes expire even if topology does not change. Other AODV options and improvements include hybrid protocols, using geographical information, energy efficient protocols, joint routing, scheduling and power control and using directional antennas.

Finally, Dr. Zussman addressed research problems. Areas of research include design and performance evaluation of cross-layered algorithms, energy harvesting active networked tags (EnHANTs), network transport, construction and maintenance of mobile backbone networks, interfaces between optical and wireless networks. Additionally, design and performance evaluation of MAC protocols includes Bluetooth scheduling, IEEE 802.11 over CATV, and MAC for networks with multi-packet reception capability. Other areas of research are distributed throughput maximization in wireless networks and algorithms for cognitive radio networks.

He then addressed mobile backbone networks (ACM MobiHoc'06, IEEE/ACM ToN'08). Regular nodes (e.g. mobile sensors) move according to their mission and have limited communication range. Using mobile backbone nodes to maintain network connectivity will create a longer communication range. The problem has been decomposed into coverage and connectivity problems, and the overall approximation ratio bounds have been obtained. Also, algorithms have been developed for the subproblems in order to maintain bounded approximation ratios under mobility.

With spreadable connected autonomic networks (SCAN), nodes move together and maintain connectivity, provide a mobile backbone, and are useful in search and rescue missions. Using real nodes is a practical consideration, for they have limited/no location information and non-deterministic connectivity patterns.

Energy harvesting active networked tags (EnHANTs), small and flexible, can be attached to almost anything such as books, furniture, produce, clothing, walls, appliances and the like. They can be used in various tracking applications. They can harvest their own energy, including solar or ambient light, piezoelectric (motion/pressure), and RF.

EnHANTs form an ad-hoc network and exchange basic information like tag IDs, partial location and status (limited sensing). They can communicate with other EnHANT friendly devices such as laptops, mobile phones, and access points.

Each EnHANT has a unique ID, with its main application to collect local IDs and then form a graph of EnHANTs. According to the energy levels, they transmit summaries, however, there are tradeoffs between energy consumption and information granularity.

Dr. Zussman then gave an example of an EnHANTs application: locating a misplaced book in a library. Books will be equipped with EnHANTs on the cover, harvest light energy, exchange only IDs (Dewey Decimal System), and communicate within a very short range (ultra-low-power). A book whose ID is significantly different from its neighbors will be identified, and the information will be wirelessly forwarded to sink nodes and from there to the librarian. A librarian accessing the shelves with a reader will be able to locate a specific book.

In drawing to a close, Dr. Zussman explained that EnHANTs is also useful in disaster recovery through usage of cellular phones for locating and tracking survivors. Tags and phones will be carried by almost anyone in a building. The tags will be embedded in the infrastructure, and phones will have short-range modes (Bluetooth and WiFi). The tags have a very short range, low data rate, and limited energy source, and the system requires constructing an ad-hoc network with no central control that is energy efficient. With that, Dr. Zussman concluded his talk.

Dr. Sat returned to the podium, and asked Dr. Zussman to assist him with the presentation of HCS student awards for outstanding work on written reports during the HCS Weekly Lecture Series. Students who received awards were: *Rodney Agnant, Isabelle Fesale, Marcia Frimpong, Jack Jenkins, Gianella Medina, and Binta Wague.*

Immediately following, Dr. Sat introduced the next student speaker, Pooja Vijay, HCS Class of 2009, and a student at Brooklyn Technical High School. Her presentation entitled "The Effect of Protein 4.1R on the Structure of Red Blood Cell Membrane," reflects her research under the mentorship of Dr. Mohandas Narla and Dr. Jianhua Zhang at New York Blood Center.

Pooja began with an introduction on red blood cells and their critical role. A single drop of blood contains millions of red blood cells that are constantly traveling through the body delivering oxygen and removing waste. If they weren't, the body would slowly die. Because of this, an essential attribute of the red cell is its ability to undergo extensive and repeated deformations while maintaining structural integrity.

She continued, saying that it has become clear that the simple model of red cell membrane organization, which endured for so long based on an irreversibly assembled membrane skeleton and a population of predominantly free-floating transmembrane proteins, is inadequate. Pooja's hypothesis suggests that the 4.1R protein organizes a macromolecular complex of skeletal and transmembrane proteins at the junctional node and that perturbation of this macromolecular complex is not only responsible for the

well-characterized membrane instability but may also remodel for the red cell surface

Protein 4.1R (4.1R) is a multifunctional component of the red cell membrane. It forms a ternary complex with actin and spectrin, which defines the nodal junctions of the membrane-skeletal network, and its attachment to the transmembrane protein glycophorin C creates a bridge between the protein network and the membrane bilayer. She continued, saying that by performing various western blots, scientists have previously shown that the membranes of mouse red cells lacking 4.1R have greatly impaired shear resistance. The same is true of human 4.1R-deficient cells. This is because deletion of 4.1R in mouse red cells leads to a large diminution of actin, accompanied by extensive loss of cytoskeletal lattice structure, with formation of bare areas of membrane.

For her experiment, Pooja's materials included a SulfoLink kit, a Cholesterol Quantification Kit, pMAL vector, MBP resin, monoclonal anti-MBP antibody, a DC Protein Assay Kit, SDS/PAGE, electrophoresis reagents, SuperSignal West Pico chemiluminescence detection kit, HRP-conjugated anti-mouse IgG, and HRP-conjugated anti-rabbit IgG.

To date, Pooja has completed a portion of the experiment, which she next detailed. In her procedure, Pooja first had to generate 4.1R knockout mice. Next, antibodies against mouse transmembrane proteins GPC, band 3, Rh, RhAG, XK, Kell, Duffy, LW, and CD47 were raised in a rabbit by using synthetic peptides as antigens. For the Phalloidin staining of red cells, freshly drawn blood was washed three times in PBG buffer. Next, mouse erythrocytes were attached to polyl-lysine-coated coverslips by centrifugation at 200 × *g* for 5 min at room temperature. RBCs were then washed three times in PBS. White ghosts were prepared by lysis of RBCs in ice-cold 5T5K buffer (5 mM KCl/5 mM Tris, pH 7.4/0.1 mM DFP) in the presence of 1 mM $MgCl_2$, followed by three washes in 35 volumes of the same buffer. Pooja's work next would involve a western blot, and she explained that it is a technique used to identify and locate proteins based on their ability to bind to specific antibodies. Hence, it can also provide information on the size of a protein and/or its expression amount. The student displayed a step-by-step diagram of the procedure as she discussed it.

For the future, Pooja plans to perform an analysis of the western blot. Aliquots of RBC ghosts, matched for cholesterol content, must be separated by 10% SDS/PAGE. The proteins will then need to be transferred to a nitrocellulose membrane. RBCs from wild-type and 4.1R knockout mice will then be washed three times in PBS supplemented with 0.1% BSA (PBS-BSA). Cells must be washed four times with PBS-BSA before flow cytometry analysis can be performed.

Pooja will then prepare recombinant proteins. The full-length 4.1R 80-kDa, GST-tagged 30-kDa, 16-kDa, 10-kDa, and 22/24-kDa domains of 4.1R must be constructed and purified as she had already described. Following, she will execute a pull-down assay. To measure the binding of 4.1R 80-kDa and its functional domains and subdomains of the 30-kDa domain to cytoplasmic tails of XK, Duffy, and Rh, 4.1R or its domains, it must be incubated with the biotin-labeled synthetic peptide at room temperature for 1 hour.

Pooja then displayed a slide of Immunoblots of membrane skeletal proteins in red cells of 4.1R+/+ and 4.1R−/− mice. She explained that blots of SDS/PAGE of total membrane protein were probed with antibodies against the indicated proteins. She pointed out the absence of 4.1R, as well as p55 in the 4.1R-deficient cells, the reduced actin concentration, and the elevated tropomyosin and adducin.

As the final slide in her presentation labeled "Schematic representation of two types of multiprotein complexes in the red cell membrane," Pooja pointed out a protein complex attached to spectrin near the center of the tetramer (dimer–dimer interaction site). Tetrameric band 3 is bound to ankyrin, which is bound to spectrin. The membrane skeletal protein 4.2, she stated, has binding sites for band 3 and for ankyrin. Transmembrane glycoproteins GPA, Rh, and RhAG bind to band 3, and CD47 and LW associate with Rh/RhAG. The two cytoplasmic domains of band 3 contain binding sites for soluble proteins, the short C-terminal domain for CA II, the large N-terminal domain for deoxyhemoglobin and for glycolytic enzymes, aldolase, phosphofructokinase (PFK), and glyceraldehyde 3′-phosphate dehydrogenase (GAPDH).

In the same slide, Pooja displayed a protein complex at membrane skeletal junctions. The junctions contain the ternary complex of spectrin, F-actin, and 4.1R, as well as the actin-binding proteins tropomyosin, tropomodulin, adducin, and dematin. 4.1R enters into an additional ternary interaction with the transmembrane protein GPC and p55 and is taken also to bind to band 3, in the form of a dimer, which also carries GPA. Rh, Kell, and XK also have binding sites on 4.1R. However, she closed by saying the copy numbers of all transmembrane proteins except GPA and GPC are low and therefore will not be present on all complexes.

Dr. Sat returned to the podium and introduced the next student presentation entitled "Questions in the Distribution of Prime Numbers." Adarsha Subick, HCS Class of 2008, and a student at Richmond Hills High School, had done his summer 2008 research under the mentorship of Prof. Gautam Chinta of City College New York Department of Mathematics.

The student first discussed general facts about prime numbers, first defining a rational prime number as any number > 0, whose only proper divisors are itself and one. The student continued to explain that all integers could be uniquely expressed as the product of prime numbers. The fundamental questions he had asked are how one determines if a number is prime, and, given any number, how one factors it into a product of prime numbers.

To first determine whether a number is prime, Adarsha had used the formula: some number (p) that divides the "prime"(n). He had begun testing an example to determine up to what value of (p) must be checked to see if it (n) is prime. The student had then addressed the question of how one determines if a number is prime, first by demonstrating the use of a sieve of Eratosthenes, an algorithm for finding all prime numbers up to a certain integer. He had next used Pari/GP, a command-based calculation program with programmable interface, in which he had been able to script new functions into the software. Using modular arithmetic, the prime numbers had been divided into groups and tested.

Adarsha concluded his presentation describing his work on Gaussian prime numbers, i.e., complex numbers. Gaussian integers are numbers in the form of a+bi, where a & b are both integers. A Gaussian integer is a Gaussian prime if its only proper divisors are ± 1, ± i, and multiples of itself by ± 1, ± i. Sometimes a rational prime is also a Gaussian prime, and sometimes it is not. Adarsha explained that rational numbers can only be factored in conjugate a + bi form. If a rational prime cannot be written in the form $a^2 + b^2$, then it is also a Gaussian prime. However, if the rational prime can be written in the form $a^2 + b^2$, then factoring it will yield Gaussian primes in the form (a±bi) and (b±ai).

The student explained that he had arranged the Gaussian primes in order of magnitude based on their "norms". This is calculated by multiplying the prime by it's conjugate, e.g.: 1+2i (1+2i)(1-2i)=5. When dealing with Gaussian Primes, they cannot be broken up into categories by modular arithmetic, as the rational primes had been. These are broken into angle categories. Adarsha concluded saying that the "angle" of a Gaussian prime is calculated by arctan(b/a).

Dr. Sat returned to the podium and introduced the next joint student presentation, "Harlem Ecological Summary and Solutions." Randy Garcia, and Jah-Vin Vaughan, both HCS Class of 2009 and students at Frederick Douglass Academy presented their research under the mentorship of marine biologist Mauricio Gonzalez and geochemist Dr. Robert Newton at Lamont-Doherty Earth Observatory.

As background to their study, the students first discussed how people fish as a hobby in the Harlem and Hudson River. This is quite unsafe, because in both rivers there are toxins that settle to the bottom. The students wanted to determine what those toxins are. In addition, the air quality around Frederick Douglass Academy (their school) is the worst in New York City, so the students wish to raise awareness with their research.

The students then furnished a bit of background on the Hudson River. At about 315 miles long, it originates at the Hoosic and Mohawk Rivers and runs between the states of New York and New Jersey. The lower part of the Hudson River is a tidal estuary, and can flow either way. Arsenic has been found in the Hudson River, albeit at the bottom. In contrast, the Harlem River, a tidal strait about 8 miles long, runs between Harlem and the South Bronx.

Randy and Jah-Vin then delved into particulate matter. They defined it as solid and liquid particles suspended in air. Most are hazardous, and can contain such substances as dust, pollen, soot, smoke, and liquid droplets. The students provided a chart that listed some of the toxins in New York City air, including benzene, naphthalene, butadiene, carbon tetrachloride, acetaldehyde, arsine and chromium.

The area in which the students' school, Frederick Douglass Academy is found has an enormous amount of particulate matter. The cancer risk associated with the school's surrounding area within a 5-block radius in any direction is higher than one hundred in a million (EPA 2009). To demonstrate their findings, the students displayed a choropleth air quality map.

The students then turned to discussing a tool they used in their research: ArcGIS, a software suite consisting of a collection of geographic information system (GIS) software programs. The main program they would be using is ArcMap, the main component of ArcGIS. It allows the user to view, edit, analyze, and create geospatial data.

Their objectives are to determine the physical/chemical parameters of the Harlem River and compare them to the Hudson River. The students also wish to determine the effect of air quality on the surrounding community's health, and propose realistic improvements.

For their work, their materials include a YSI OMS600, pH YSI 556, buffer solutions (pH 4, pH 7), and computer with Excel program, distilled water, PVC pipe, PVC glue, drill and drill bits, ruler, spray paint, and an inflatable boat. They also require both a CO2 sensor and an O2 sensor.

To date, the students have taken oxygen, temperature, pH, and salinity measurements from the Harlem River. As well, they have taken water samples from the Hudson River and have been working with ArcGIS. The students mentioned that they are tangentially investigating a curious sub-tropical fish that their mentor had recently identified in New York waters.

In terms of possible solutions to propose to improve conditions, the students have considered urban farming, vegetation therapy, alternative transportation, alternative energy sources, water management and further research.

The students' concluded by discussing their future plans to take and analyze more measurements from the Hudson River. They plan to show the levels of the different parameters on maps generated by ArcGIS, and add Frederick Douglass Academy to the E.P.A. monitoring program. Additionally, as a side project, they would like to design a pier to be constructed behind their school.

The next joint presentation was made by Darleny Lizardo HCS Class of 2008, and a student at Bronx Health Science High School, and Carolina Nunez, HCS Class of 2008, and a student at High School for Medical Science. The students had worked under the mentorship of Stephanie Pitsirilos-Boquin MPH on "Research in Nutrition and Healthy Living: Geographic Variations in Produce Prices" in summer 2008.

The students' project, part of a larger project on obesity, had focused on comparing price and quality of produce from farmer markets versus neighborhood supermarkets in four different locations in New York City. The students discussed the difference between obesity and being overweight. Obesity is the proportion of the total body fat, characterized by a body mass index (BMI) of 30+. The condition of being overweight is defined by a body mass index of 25-29.9.

The group with whom the girls had worked had wanted to research the difference in the price of produce in farmer markets and supermarkets, and if/ how these differences might affect the risk of obesity. They mentioned that they expected that higher prices at farmer's

markets would discourage healthy nutrition habits. To collect their data, they selected farmers markets in Harlem, Inwood, Union Square, and Washington Heights.

Their procedure had been to collect price unit information on a set list of produce based on weight, volume or bunch. The students found a clear variation in prices, and determined that there was greater value in volume and freshness in the farmer market produce. They attributed the higher cost of supermarket produce to such factors as business and shipping costs, among others. In the future, the students would like to conduct further field surveys focused on shopping habits, the relationship between location of shoppers, their nutrition habits, as well as the relationship to obesity risk.

This summer, the students' new research continues on the obesity project. They described how they are working in 12 groups, each with a leader. Each group is assigned to visit specific locations: supermarkets, corner stores, or farmer's markets. Data is being collected related to income, household locations, availability, education and quality of the foods available. Risk factors of obesity are also being studied.

The girls stated that last year they had concentrated only on produce, but this year they are concentrating on that aspect along with the types of people that shop in certain places and why certain locations are the way they are. They are using GIS and statistics in their research in order to keep better track of their data.

They then provided a brief description of GIS, Geographic Information System. A computer program used to research locations using maps, it produces layers of information that allow one to examine other factors, such as demographics of any given area without having to physically see it. It provides many maps that facilitate better understanding an area under investigation.

Dr. Sat then approached the podium to offer his suggestions on the girls' presentation, and to introduce the next and final student presentation of the day. The presentation was "Rett Syndrome," given by Thahmina Aktar Ali, HCS Class of 2008, and a student at High School for Medical Science. Under the mentorship of Dr. Thomas Brennan and Mrs. Joan McMahon, the student had done her summer 2008 at Bronx Community College in the Chemistry Department as part of the Bioinformatics Summer Workshop.

The student first defined Rett Syndrome as an inherited disease of the nervous system and childhood neuro-developmental disorder. The disorder leads to developmental reversals in the areas of expressive language and hand use, slow progress of brain and head growth, gait abnormalities, seizures, and mental retardation. Thahmina then linked the study of Rett Syndrome to Bioinformatics based on the fact that it is an inherited disorder with a mutation found on the X chromosome, part of the human genome. Bioinformatics, which emerged from the Human Genome Project, is a way to organize, search, analyze and store the millions of DNA gene sequences on computer.

The student then went into the history of the disease, named for the Austrian physician, Dr. Andreas Rett, who in 1966 identified it. Dr. Rett never identified the gene involved, but was responsible in 1954, for noticing and observing two girls sitting in his

waiting room who made repetitive hand-washing motions. He compared their clinical and developmental histories and found they were very similar to six other girls with the same behavior, and concluded that they all suffered from the same disorder.

In 1999, Rett syndrome was determined to be caused by mutations in the MECP2 gene. The discovery of the gene MECP2 located at the Xq28 site on the X chromosome proved that Rett syndrome is an X-linked disorder. Only one of the two X chromosomes must have the mutation to cause the disorder. Since Rett syndrome is an X-linked dominant disease, this explains why it is almost exclusively found in females. Females have two X chromosomes, so when even one has the defect, the other X chromosome provides enough normal protein for the female to survive and yet still carry the disorder. Seventy to eighty percent of females diagnosed with the disease have the MECP2 genetic mutation.

In terms of gene function, Thahmina explained that MECP2 is a member of a family of proteins all containing a Methyl-CpG Binding Domain (MBD). Other family members are MBD1, MBD2, MBD3 and MBD4. The MECP2 gene provides instructions for making a MECP2 protein that is critical for normal brain development. The MECP2 protein plays a role in forming connections between nerve cells, including regulating other genes in the brain by switching them off when they are not needed. A missense mutation occurring in the MECP2 gene changes only one amino acid of the gene, thus changing the entire configuration of the protein. Proteins then become tightly packed in the MBD. Hence, MBD is crucial for MECP2 function.

The student then went into her goal to understand the alignment of MECP2 sequences of different species with the positions of the mutations in Rett Syndrome using the National Center for Biotechnology Information (NCBI) Basic Local Alignment Search Tool (BLAST). Her procedure had first involved obtaining the messenger RNA sequence of the MECP2 gene using the National Center for Biotechnology Information (NCBI) website. Next, she implemented the program, Basic Local Alignment Search Tool (BLAST), a database designed to explore all of the available gene sequences and to receive the different sequences that the MECP2 will compare. Subsequently, the results from BLAST of the sequences were analyzed. And finally the search was narrowed down to compare the human MECP2 sequence with three other organism sequences, e.g., mouse, chicken, and X-*laevis* (African Clawed frog).

Thahmina then discussed the symptoms of the disease. A child can begin life developing normally aged 6–8 months before the onset of symptoms. Gradually, mental and physical symptoms appear, including: loss of muscle tone, diminished eye contact, severe issues with or loss of speech, loss of purposeful hand movements (often repetitive wringing and/or washing), apraxia (problems with crawling or walking), and loss of social engagement.

The stages of Rett Syndrome are classified as follows: 1) Early Onset Phase – characterized by lack of development after initial growth period of 6-18 months; 2) Rapid Destructive Phase – characterized by hypotonia, i.e., loss of hand movement and speech; 3) Plateau Phase – characterized by what appears to be a lessening of symptoms, and the phase in which most patients remain for their lifetime; 4) Late Motor Deterioration Phase

– characterized by apraxia, i.e., the loss of movement and muscle tone in which some patients may become immobile.

As for treatment, the student stated that Rett syndrome has no cure. However, the symptoms associated with the disorder can be treated in ways to retard the loss of physical ability, improve movement, and encourage communication. Such treatments include physical therapy, occupational therapy and speech-language therapy.

While rare, the disease can occur in all racial and ethnic groups, with a ratio worldwide of 1 out of every 10,000 to 23,000 female births. Although Rett syndrome is a genetic disorder, the inheritance is dominant if one copy of the mutated gene is sufficient to cause the condition. Males who have an MECP2 mutation only have one X chromosome lack the back-up copy that could compensate, and therefore die shortly after birth.

As for future research, Thahmina stated that The National Institute of Neurological Disorders and Stroke (NINDS) and the National Institute of Child Health and Human Development (NICHD), two National Institutes of Health (NIH) facilities, are continuing to research how the MECP2 protein functions. The information from this study will increase understanding of the disorder, and perhaps provide a basis upon which to develop new therapies. Thahmina concluded the fourth seminar of the HCS 2009 summer program, stating that a possible outcome of the research may involve manipulating other biochemical pathways to compensate for the malfunctioning MECP2 gene, thus preventing progression of the disorder. The meeting was then adjourned.

§§§