High School Science Apprenticeships at HWI

For over 10 years, City Honors High School of Buffalo has had a program designed to give talented young people an opportunity to learn more about medical research. In 2006, the Hauptman-Woodward Institute (HWI) began to participate in the program. At HWI, qualified students from City Honors work in the laboratory of the H. A. Hauptman Distinguished Scientist, Dr. William L. Duax. The goal of Dr. Duax's research is to develop an understanding of how the genetic code itself evolved.

At City Honors, freshmen who are interested in a research apprenticeship come to school an hour early for the first six weeks of the school year to learn how to write an application for admittance to the program. Students who are accepted spend every Friday throughout their high school careers in a research laboratory. In addition, they are asked to work in the lab for four additional hours each week and to spend part of their summer vacation in the lab.

History

Dr. Duax currently has five City Honors students working in his lab. His first student, Jimmitti Teysir, began the apprenticeship program in 2007. In 2009, she was one of 1500 finalists at the Intel science competition in Reno, Nevada, where she won a $9000 scholarship.

In 2008, three students from Dr. Duax's lab (Jimmitti, Dana Hogan and Tyler Kirsh) were the only high school students to present their work at a regional college undergraduate math and science day in Niagara Falls. Their lucid presentation of novel methods for predicting the targets of an ancient family of enzymes (proteins) critical to growth and survival stunned the audience. The talented trio also presented their talk at HWI where a reporter, who covered the event for the *Buffalo News*, referred to Dr. Duax as "the pied piper of bioinformatics".

Soon, students from other schools in the area were asking how they could get into the program. A student presentation to the participants in UB's gifted math program drew more applications. Anyone willing to spend four hours a week was welcome. By the summer, there were ten students working in the lab. They began an in-depth study of a bacterium with very unusual DNA. This bacterium is a living relic that holds the key to understanding the origin and evolution of the genetic code, and evolution of the code parallels the evolution of the species.

There were 25 students from 12 schools in the program in the summer of 2009. At a public reception, 16 students mingled with the guests, explaining why they wanted to dedicate their life to medical research and describing what attracted them to the HWI program. Dr. Duax commented that these students' ability to communicate the essence of their work to a wide audience ranging from grade school students to university professors is a skill that many scientists never achieve.

The 2011 program was held 6 hours per day, 5 days per week, from June 21 to July 23. Nine teams of 2 or 3 students, each led by a veteran of the program, were assigned individual projects (that is, analysis of one of the 50 proteins present in the ribosome) and began PowerPoint presentations by the third day. Each student gave a report on a different bacterial species. On day 15 of the program, students were reorganized into teams to conduct comparative analysis of the results of different aspects of the individual studies, and a PowerPoint presentation of an overview of the studies was prepared and presented to the scientific staff of HWI. All members of the team participated in the one-hour presentation. Since the end of the formal school, a dozen students have continued independent, but supervised, study involving preparation of manuscripts for publication on the ribosomal protein they analyzed.

Summer School 2012

Tentatively, the dates for the 2012 Summer School will be Monday, June 25, to Friday, July 27. The schedule can be adjusted to accommodate individual needs. School will be in session five days a week for the five weeks with one hour per day of formal lectures and one hour per day of tutorials. Two hours of student presentations are scheduled for every Friday.

Program Outline

There are three levels of student participation in the research apprenticeship program at HWI: (a) all day Friday for students in City Honors School in Buffalo, (b) one or two afternoons after school for students in any Buffalo area school throughout the school year, and (c) summer internship of 5 days a week for up to 12 weeks.

The four major goals of the research are to determine (1) the origin and evolution of the genetic code, (2) the order of evolution of all bacterial species, (3) the nature of evolution of the sequence and function of families of proteins present in all species, and (4) the amino acid residues responsible for drug specificity in families of enzymes.

The students do **not** replicate previous experiments for which the results are already known. Instead, they conduct experiments that have never been done before and that challenge basic tenets of molecular biology. In this way, students learn that genuine research demands flexibility, adaptability, creativity and patience.

Training is computer intensive. The students learn to use state-of-the-art computer programs for amino and nucleic acid sequence analysis of the genomes of all bacteria and eukaryotes. The training includes the use of the most heavily used programs for biological analysis on the worldwide web and a suite of unique programs developed at HWI for proteomic and genomic analysis. The students mine the data in the gene and protein banks of the world.

The students are given opportunities to present their research goals and results and their interpretation of their data to coworkers, classmates, laymen, and scientists. They learn to organize and focus their presentations at an appropriate level for each of these audiences. The students are offered the opportunity to be fully qualified coauthors of abstracts published in the proceedings of national and international scientific meetings and manuscripts submitted to leading scientific journals. Qualified authorship requires that the student make significant contributions to the gathering and analysis of data critical to the publication and that the student has a full grasp of all details and aspects of the work and the manuscript.

A. Applications

Students must complete a detailed application that is based on the City Honors application (download here). Students are asked to describe their goals and aspirations and explain why they want to study the biological sciences. The applications are evaluated for interest level, evidence of suitability for a career in research, and potential for successful completion of the program.

After their applications have been reviewed, students are interviewed (often in the company of a parent) and given a tour of HWI research facilities. They receive an overview of the goals of the research project, the potential role they will play in the project, and a description of what will be expected of them. So far, no student who has completed the application form has been denied entry to the program. In the future, however, increased demand may make it necessary to rank the applications and accept only the most promising candidates.

B. Procedures

On their first day, students who are accepted into the program learn the goals of their immediate data collection assignments. Methods are described, and students begin to gather data with minimal explanation of the relationship between the data and their ultimate goal. They are "thrown into the deep end of the pool", but this has proven effective.

By the end of the first 7 to 10 days of the program, students begin to prepare PowerPoint slides summarizing and organizing the data they have collected, identifying patterns, and suggesting possible relationships to the goals of the project as they understand them. Student PowerPoint presentations are usually given on Fridays at the weekly lunchtime "show and tell".

Each student is given individual responsibilities and becomes the student expert in the use of a specific computer program for data gathering, illustration or analysis. The student is then responsible for instructing others on the use of that program. In other words, Dr. Duax and his college or graduate-student assistants train one student who then trains the others. Students are assigned a subset of the data to be gathered about which they are to become the expert. They prepare a detailed analysis and report. They will be assigned a family of proteins and a class of bacteria. When students have sufficient data and a reasonable grasp of the potential significance of their work, they are encouraged to draft a manuscript for submission to a suitable scientific journal of their choice.

C. Presentations

Students are encouraged to present their work: (a) to fellow students in appropriate classes at their high school, (b) at local, regional and state-wide science fairs and scientific symposia (e.g. UB's Gifted Math & Science Program), (c) at regional college undergraduate math and science symposia, (d) at meetings of the HWI scientific staff, (e) at national meetings of the American Crystallographic Association (ACA) and other appropriate Scientific Societies (Molecular Evolution, Biochemistry, Biophysics), (f) at meetings of the Board of Directors of the HWI, and (g) to parents and laymen invited to attend the Friday lunches.

D. Evaluations

Each student is evaluated in terms of initiative, commitment, interpersonal skills, work ethic and dependability. Students submit detailed evaluations of the strengths, weaknesses, and highlights of the apprenticeship program. They are asked to describe what they have gained from the experience as well as where they see a need for specific improvements in the program. All student evaluations are taken into consideration in modifying the program to increase its effectiveness.

E. Benefits

Other valuable benefits provided by the program include learning how to handle media interviews (newspaper and television), opportunities for independent and cooperative investigations, and experiencing the synergy resulting from interaction with a true intellectual peer group irrespective of gender, ethnicity or economic status. Opportunities for social interaction with the peer group include picnics with parents and splat ball outings.

Most of the students have many other interests including music, literature, sports, art, business entrepreneurship, computer games and challenging puzzles. These interests contribute to the stimulating environment.