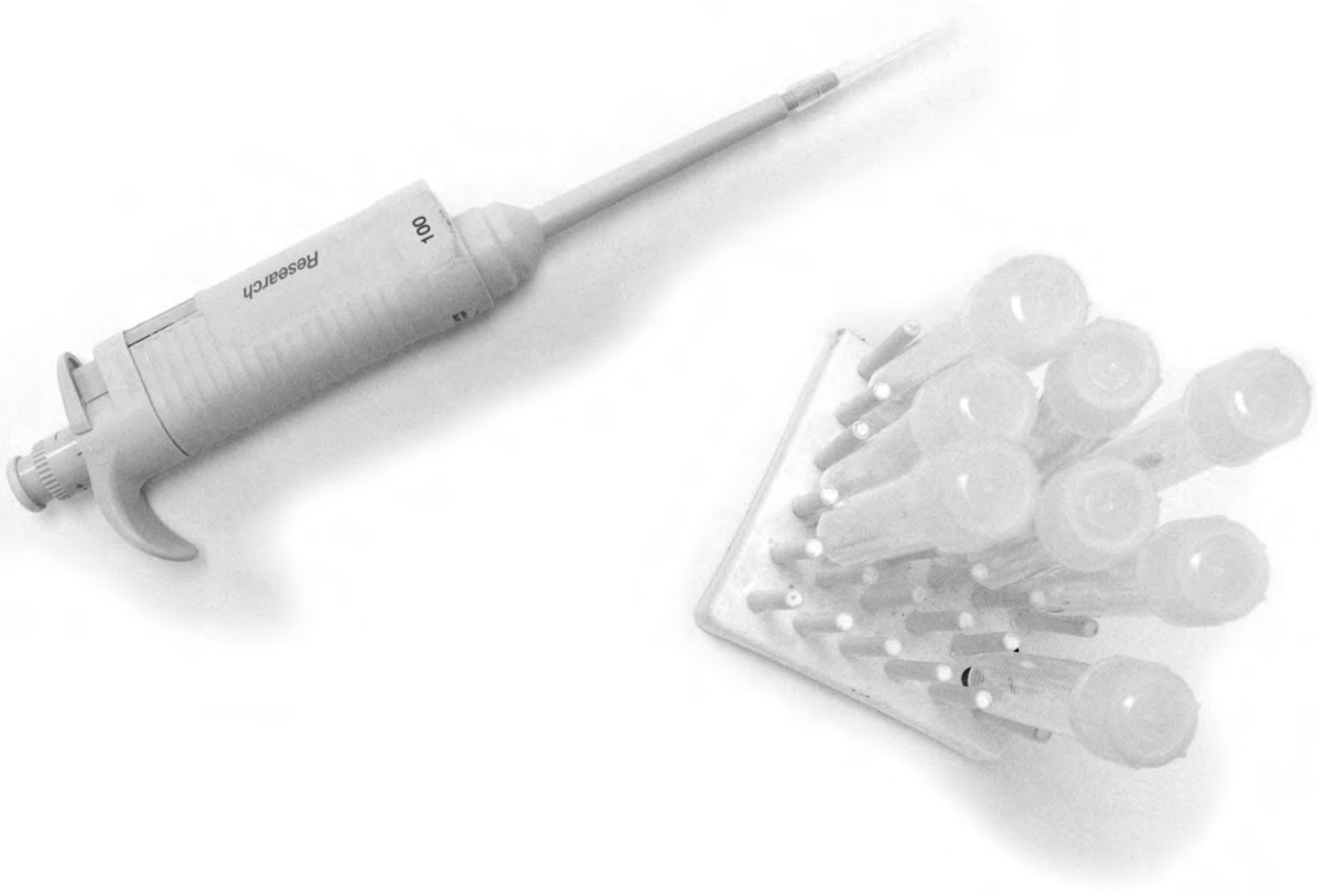
Dolan DNA Learning Center

Annual Report 2006



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DOLAN DNA LEARNING CENTER
EXECUTIVE DIRECTOR'S REPORT

Preparing students and families to thrive in the gene age

What does it mean to be human? The philosopher, theologian, sociologist, historian, scientist, and every man or woman on the street have different answers to this question. So, too, does the genome biologist who determines and compares the complete genetic endowments of living entities.

The human genome is composed of 25 kinds of chromosomes—22 autosomes, the sex chromosomes X and Y, and the mitochondrial chromosome. Each chromosome is a package for a single, long, and unbroken strand of the molecule deoxyribonucleic acid (DNA). The exact sequence of A, T, C, and G nucleotides that compose the DNA molecule running through each chromosome is unique to each person. Arrayed along the chromosomes are approximately 30,000 genes—stretches of DNA ranging from several hundred to several million nucleotides—that carry the "genetic code" for making the protein components of living cells. This code determines physiological and psychological "traits" that we inherit from our parents, thus setting the parameters of human life, health, and happiness.

The human genome weighs in at about 3 billion nucleotides, and the genomes of any two people are 99.9% identical. Expressed another way, DNA from two people will on average differ by about one nucleotide per 1000. This does not seem like much, but taken over the entire genome, it comes to 3 million differences. The same sort of reasoning applies to our closest living relative, the chimpanzee, whose genome is 99% similar to ours. This leaves room for about 30 million DNA differences between humans and chimps.

These differences are caused by mutations that accumulate in DNA over time, so the number of mutations is roughly proportional to the amount of time since two groups have diverged from a common ancestor. The majority of these DNA differences between humans and chimps are of little or no consequence. This is because only about 1.5% of the human DNA sequence actually carries the code for making proteins. Thus, by chance, most mutations are likely to occur outside of protein-coding regions. Even protein-coding regions can tolerate a good deal of mutation, for two reasons. First, the genetic code is redundant, such that a number of different nucleotide sequences can specify the identical protein. Second, some physical changes in a protein do not actually alter how it functions.

These gross comparisons can only tell so much. Better to compare individual genes. As one might expect, a number of genes have evolved (changed) rapidly since humans and chimps diverged from a common ancestor about 6 million years ago, including those involved in immunity, reproduction, smell, taste, skin, and hair. Especially intriguing are changes in a gene called *FOXP2*, which may have had a role in language development.

Even so, gene-to-gene comparisons confirm that the vast majority of human and chimp genes are functionally identical. This "conservation of function" extends throughout the evolutionary tree. Beyond

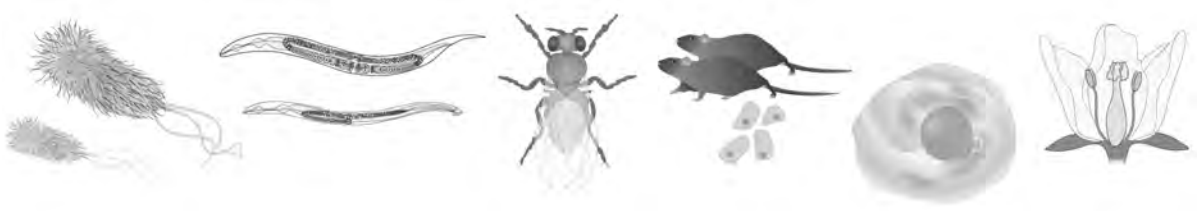
computer comparisons of gene and protein sequence, functional equivalence is convincingly shown by gene-transfer experiments, most commonly when a human gene is inserted into a living mouse to replace its mouse counterpart. In most cases, the human replacement gene functions admirably. This has led researchers to introduce human disease genes to create mouse models that mimic human disorders such as Alzheimer's disease, Huntington's disease, Parkinson's disease, and breast cancer. There are even examples of human genes functioning perfectly well in yeast, the simplest form of advanced cell.

The recent sequencing of the sea urchin genome traced elements of our genealogy even further back in evolutionary time. Surprisingly, the urchin has the most well-developed immune system yet encountered in an animal without a backbone. The urchin shares with us prototypes of genes for key growth factors and receptors that participate in immune and blood system development, including tumor necrosis factor, interleukins, and vascular endothelial growth factor. Going back further still, we share a basic set of genes—including those needed to extract energy from food—with the ancient archaebacteria that inhabit hot springs and deep-ocean vents. These gene comparisons illustrate that evolution has preserved gene "tool sets" that successfully carry out life processes—layering on new gene sets as organisms gained complexity.

Organism	Genes (Nucleotides)	Genome Size Sequenced	Year
Archaebacterium (*Methanococcus maripaludis)*	1,880	1.7 million	2007
Bacterium *(Escherichia coli)*	4,400	4.6 million	1997
Baker's Yeast *(Saccaromyces cerevisiea)*	6,190	12.1 million	1997
Fruit Fly (*Drosophila melanogaster)*	~14,800	180 million	2000
Roundworm *(Caenorhabditis elegans)*	~21,000	100 million	1998
Sea Urchin *(Strongylocentrotus purpuratus)*	~23,300	814 million	2006
House Mouse (*Mus musculus*)	~30,000	2.5 billion	2002
Human (*Homo sapiens*)	~30,000	3.2 billion	2003

As shown in the table, adding genes can add only so much complexity to an organism. Bacteria, single-celled organisms without an organized nucleus, get by with several thousand genes. Yeasts gain an organized nucleus with only about twice as many genes. The fruit fly gains a complicated body plan and external skeleton with only about twice again as many genes. Mammals gain an internal skeleton and temperature regulation with only about twice the number of genes as a fruit fly. Here, the gene number levels off, with essentially no difference in gene number between a mouse and a human.

Clearly, humans share many genes with other organisms—especially other mammals. If this is so, how can we achieve "humanness" with essentially the same gene set as a mouse or a chimp? Much of the answer lies in "noncoding" DNA sequences that do not carry the genetic code for making proteins. Much of the noncoding DNA lies in between genes, separating them from one another on the chromosomes. This "intergenic" DNA contains key regulatory sequences—promoters and enhancers—that turn genes on and off in specific tissues and at specific times during development from embryo to adult. Altering the timing and interaction of thousands of genes can produce markedly different mor-



Model organisms (left to right) *E. coli*, *C. elegans*, *Drosophila*, mouse, human cell, and *Arabidopsis*.

phological features. For example, the same set of regulatory genes defines the basic body plans of all animals with twofold (bilateral) symmetry. These "master" genes function in organisms as diverse as fruit fly to human, controlling the proper placement of body parts, from wings and antenna to arms and ears.

In the mid-1970s, Rich Roberts, at Cold Spring Harbor Laboratory (CSHL), and Phil Sharp, at the Massachusetts Institute of Technology, discovered that genes themselves are interrupted by noncoding sequences. They shared the Nobel Prize for showing that noncoding sequences—termed "introns"—separate the genes of higher organisms into modular coding "exons." The average human gene contains seven exons that can be joined together in different combinations to specify several different proteins. This "differential splicing" further increases the functional complexity of the genome.

Transposons, the so-called jumping genes discovered by CSHL Nobel laureate Barbara McClintock, are the largest component of noncoding DNA, equal to about half the total mass of the human genome! It could be worse, transposons account for an estimated 85% of the corn (maize) genome. Biologists are split about whether jumping genes serve some purpose in genome evolution or are just extremely effective genetic hitchhikers. Grand scheme or not, the most common human transposon, termed *Alu*, provides a sequence that is used in about 5% of differentially spliced exons.

Introns and transposons account for most of the disparity between genome size and gene number as organisms increase in complexity. Thus, although the fruit fly genome is about 100 times as large as the archaebacterial genome, it contains only about eight times as many genes. About twice as many human genes occupy about 18 times as much space as the fruit fly genome. Comparing extremes, human genes occupy about 100 times the genome space of an equivalent number of archaebacterial genes! Thus, from a genomicist's point of view, being human is a large endowment of genes shared with many organisms through evolutionary time, retasked by regulatory elements, and reshuffled through differential splicing. Gene sets for a basic bilateral body plan and mammalian way of life are further modified by a relatively small set of genes peculiar to our kind. Inherited gene variations are further shuffled during the generation of parental sperm and egg. This shared heritage, attenuated by a unique set of mutations, comes together at the moment of conception to produce a unique individual—one with a brain that is capable of pondering why so much of his or her genome is given over to jumping genes.

Dynamic Gene

The more than 130 billion nucleotides of DNA sequence residing in Genbank and other databases now challenge biology students to come to grips with the complex genomes of higher organisms. The geneticist J.B.S. Haldane once famously said that the universe is not only stranger than we imagine, but may be stranger than we can imagine. He might as well have been talking about the human genome, chock full of noncoding introns and transposons, as well as a new class of RNA genes, that interact in unexpected and still largely unknown ways to regulate gene expression. Thus, in 2006, we continued our work with CSHL researchers to develop interfaces to DNA databases, which open a window on the strange and wonderful world of genome science.

The *Dynamic Gene* Internet site (www.dynamicgene.org) is the educational outreach component of *Gramene*, an online resource for analyzing and comparing genes from plants in the *Gramineae*, or grass, family. This group includes the cereal grains that feed most of the world's people—rice, wheat, corn, barley, sorghum, millet, oats, and rye. The site is being developed in collaboration with CSHL genomicists Doreen Ware and Lincoln Stein, as well as three faculty producers: Debra Burhans (Canisius College, Buffalo, New York), Charlie Gutierrez (John H. Reagan High School, Austin, Texas), and Bob Wheeler (Pine Creek High School, Colorado Springs, Colorado).

The site is designed to let students learn about plant genomes by using bioinformatics to analyze genes in the newly sequenced rice and maize genomes. Many of these genes have only been predicted by computers and have never been closely examined by human beings! The site's name emphasizes the gene both as a dynamic structure that changes through evolutionary time and as a dynamic concept that changes with our increasing knowledge of genome organization. The design for *Dynamic Gene* recalls the "streamlining movement" that influenced design during the middle of the 20th century with ideas borrowed from aviation and automobile design.

Animated tutorials in the first three sections—*Meaning*, *Structure*, and *Evidence*—illustrate (1) how DNA sequences encode biological information, (2) how bioinformatics uncovers sequence patterns that predict the structural components of genes, and (3) how computer-generated gene "models" are annotated with gene features and evidence from biological experiments. The *Annotation* section provides step-by-step instructions on how to analyze a gene model with *Apollo,* research software that was used to annotate the *Drosophila* genome. Once students understand the basics of gene annotation, they go to the *Projects* section to download large DNA sequences from cereal chromosomes. They then pit their logic against the computer that predicted the gene models encountered and upload their new annotations to share with other researchers.

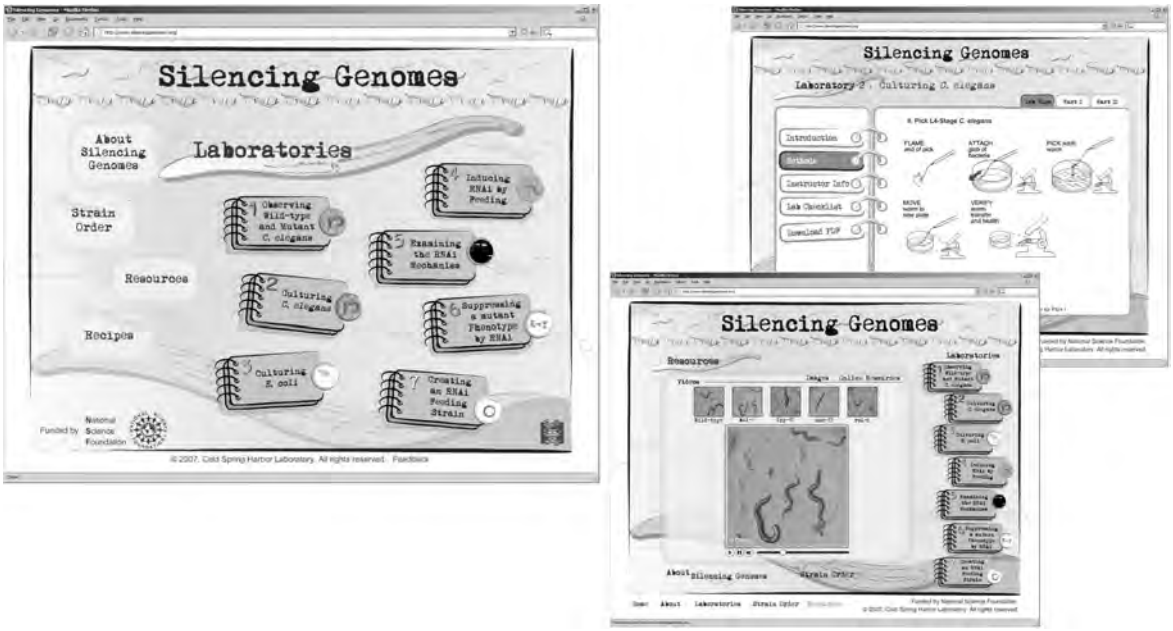
Bringing Nobel-winning Science to Students

With complete genome sequences accumulating at an accelerating rate, ahead lies the massive task of determining the physiological function of thousands of newly identified genes for which little is known beyond their sequences. The 2006 Nobel Prize in Physiology or Medicine recognized the discovery RNA interference (RNAi), a basic mechanism of gene regulation that also provides an important new tool for functional genome analysis. American scientists Andrew Fire and Craig Mello shared the Prize for showing that short, double-stranded RNA (dsRNA) molecules can down-regulate gene expression of a corresponding target gene. By deliberately introducing defined sequences of dsRNA into living organisms, biologists can observe the physiological consequences of "silencing" virtually any gene in *Caenorhabditis elegans*, as well as other plants and animals. MicroRNAs, which use part of the RNAi mechanism, have emerged as a powerful force in large-scale gene regulation and genome organization. CSHL researchers Greg Hannon, Leemor Joshua-Tor, and Scott Lowe have pioneered work on the mechanism of RNAi and its adaptation as a tool for genome exploration.

Despite its power, RNAi is amazingly simple to perform in the roundworm *C. elegans*, an important model system for eukaryotic gene function. Any gene of choice can be "silenced" merely by feeding worms bacteria that express the correct dsRNA. In its simplest form, RNAi requires little more than the ability to grow bacteria and observe *C. elegans* traits with a dissecting microscope. The vast majority of high schools and colleges meet these requirements, making RNAi in *C. elegans* potentially more accessible than other molecular techniques for which specialized equipment is required, such as polymerase chain reaction (PCR) and gel electrophoresis. For these reasons, we have devoted considerable effort to developing the RNAi*/C. elegans* system as *the* vehicle to deliver functional genome analysis into high school and college classes.

Considering the banner year for RNAi in Stockholm, our timing could not have been better as we completed our National Science Foundation project to develop an integrated experiment- and bioinformatics-based curriculum on RNAi in *C. elegans*. The curriculum begins with observation of mutant phenotypes and basic worm "husbandry," and then progresses to simple methods to induce RNAi and to use RNAi to rescue (compensate) a mutant phenotype. A more advanced experiment uses "single-worm PCR" to examine the mechanism of RNAi— comparing the DNA of worms with identical phenotypes induced by either RNAi or a gene mutation. The curriculum culminates with open-ended methods that support student projects. Students can perform RNAi "from scratch" using bioinformatics to develop PCR primers for a target gene, then cloning the amplified product into an RNAi feeding vector, and finally observing the phenotype of treated worms. Students also have free access to the DNALC's collection of RNAi feeding strains, which can be used to conduct a miniscreen to identify genes involved in a particular biological pathway.

An online lab notebook, *Silencing Genomes* (www.silencinggenomes.org), combines lab methods with user-friendly features adapted from the DNALC's popular text *DNA Science*, including flow charts, reagent recipes, and extensive instructor information. Supporting resources include photos and video of *C. elegans* mutants, as well as a simple checkout system to obtain any of 80 *C. elegans* mutants and *Escherichia coli* feeding strains. The Internet site also provides a launch pad for bioinformatics exercises that accompany each experiment. Students use online databases—including *WormBase* and *Pubmed*—to explore the molecular genetics and physiological functions of the genes targeted by RNAi.



NCBI's BLAST and the DNALC *Sequence Server* are used to explore the evolutionary relatedness of genes in worms and humans.

The experiments were initially tested during a spring workshop of our Advisory Panel of 12 lead high school and college faculty from around the United States. Building on their feedback, the curriculum was then field-tested at summer workshops in Oklahoma City, San Francisco, and New York City, which were attended by 53 high school teachers, 6 junior college faculty, and 9 four-year college faculty. In addition, the RNAi curriculum was a major focus of the Amgen *Leadership Symposium* and workshops conducted for the Singapore Ministry of Education and the Novartis Exploratory Clinical Development Group.

To get a quick picture of early classroom implementation, in December, we administered an online survey for faculty who participated in testing summer workshops. The majority (71%) of respondents had already begun to integrate workshop content into their teaching, by using RNAi (51%) or *C. elegans* (41%) as examples while teaching about other topics or by teaching entire units of RNAi (37%) or *C. elegans* (16%). This teaching impacted 1781 students and 58 other teachers. More than a quarter (27%) had done one or more labs—basic *C. elegans* manipulation and mutant analysis (25% each), RNAi by feeding (16%), analyzing mutants by PCR (12%), and generating a targeting vector (4%). This lab instruction impacted 329 students and 17 teachers. The same proportion (27%) had used bioinformatics to analyze *C. elegans* genes or to compare worm to human genes, impacting 410 students and 19 teachers.

Real-time Microscopy Exhibit

The DNALC's museum exhibits are tightly tied to experiments that students conduct in the teaching labs. For several years, an Applied Biosystems 307 DNA sequencer did double duty as an exhibit as it sequenced mitochondrial DNA samples isolated by students in the teaching labs and submitted from schools around the United States. As our volume increased to more than 5000 student sequences per year, we shifted this work to a faster capillary machine at the CSHL Genome Center. In 2006, this space was taken over by a new Nikon Eclipse 80i microscope, with fluorescence and differential interference contrast (DIC) optics. A high-resolution digital camera output to a 46-inch LCD display allows us to display striking, live images taken from the microscope.

Real-time exhibits prepared each day give students a glimpse of the world as seen through this research-grade microscope. As a default, live mounts of *C. elegans* mutants, including the bizarre "bag of worms," coordinate with an adjacent exhibit on key model systems used in biological research. At

Educator Lauren Weidler focuses in on *C. elegans* with the Nikon fluorescence microscope and flat-panel display newly installed in the exhibit space.

other times, mounts complement a variety of labs conducted by 5th to 12th grade students. Cells scraped from an instructor's cheek, or stained chromosomes spreads, show the source of student DNA for human PCR. Live *E. coli* or *C. elegans* expressing green fluorescent protein (GFP) vividly illustrate the results of student's own efforts to genetically engineer bacteria with the GFP gene. Mounts of plant and animal cells, as well as *C. elegans* mutants, reinforce student observations of differences in cell structure and variations in phenotype.

DNA Sequencing Service

The DNA Sequencing Service continued to offer students nationwide the opportunity to look at their own DNA sequence and to use it as the basis for understanding human diversity. Every human cell has a "second" genome, found in the cell's energy-generating organelle, the mitochondrion. Mutations are common in part of the mitochondrial chromosome, largely due to exposure to oxygen-free radicals generated as a by-product of energy production. Because of this mutational variability, the noncoding region of the mitochondrial chromosome is a mainstay in studies of human variation and evolution.

The DNALC popularized methods to use mitochondrial mutation analysis in education, focusing on the same region of DNA featured in the National Geographic's Genographic Project and the popular book *The Seven Daughters of Eve*. Using DNALC protocols or ready-to-use kits, students isolate a 440-nucleotide sequence of their mitochondrial genome, and then send their samples by overnight mail to the DNALC. At the DNALC, college interns Alina Duvall (Hofstra University) and Jennifer Aiello (Long Island University) perform dye terminator reactions that label student samples for DNA sequencing. The reactions are then sent to the CSHL Sequencing Shared Resource Facility in Woodbury, where they are sequenced on an Applied Biosystems 3730xl Genetic Analyzer. The finished sequences are uploaded to a student DNA database at the DNALC's BioServers Internet site (www.bioservers.org).

Using bioinformatics tools at the Internet site, students can compare their own mitochondrial DNA with their classmates' to see that people have inherited unique patterns of mutations. In comparing mitochondrial DNA samples from world populations, students can understand the evidence for the human lineage developing in Africa and recently migrating "out of Africa" to populate the rest of the world. Students can also compare ancient DNA samples from Neandertals and Otzi "the ice man" to understand their relationships to modern humans.

In 2006, we sequenced 6400 students' DNA samples submitted from 31 states, Washington, D.C., and Canada. On average, results were posted on the Internet site within 12 days of receipt. This unique educational system—DNA sequencing, student DNA database, and Internet bioinformatics tools—is provided free of charge to high school and college classes. This is made possible by the donation of sequencing reagents by Applied Biosystems of Foster City, California.

Genes to Cognition Online

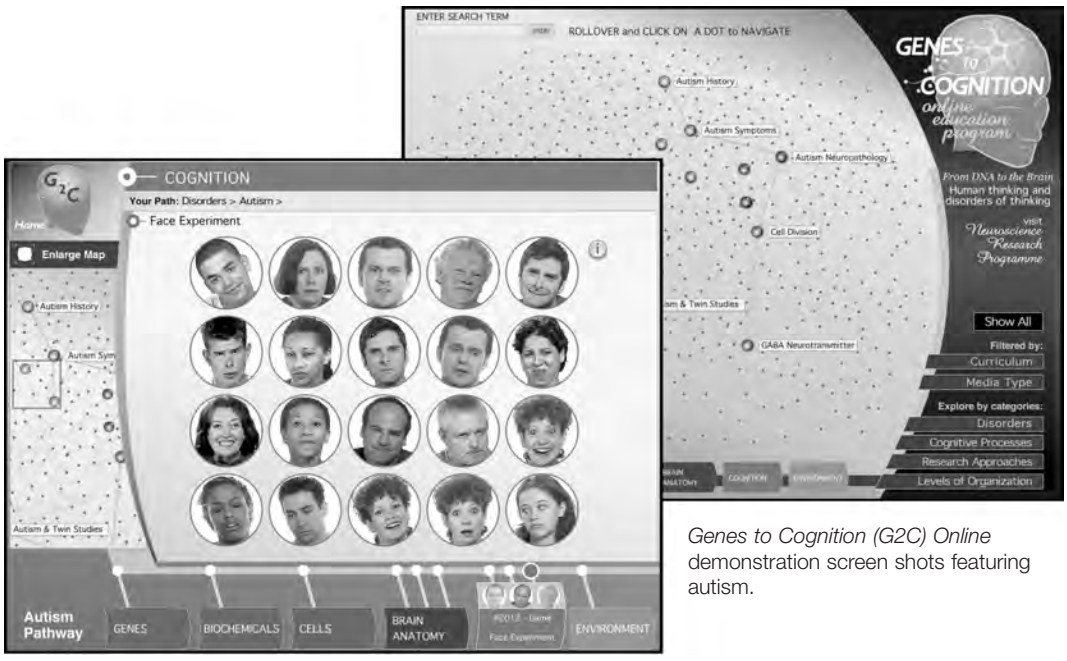
We continued with key formative work on the new Internet site, *Genes to Cognition* (*G2C*) *Online*, which will explore the molecular basis of human thinking and disorders of thinking. During the first part of the year, we worked closely with advisory panelist and education pioneer, Joe Novak, to develop methods to obtain detailed concept maps in three knowledge domains: cognitive disorders, approaches to sci-

ence, and systems-level biology. These concept maps form the backbone of the *G2C Online* "knowledge network," which guides content development and defines how different content items are related to one another. Thirteen experts from neuroscience and education were interviewed:

- Eric Kandel (Nobel laureate, Columbia University): Basic memory mechanisms
- Steve Hyman (Harvard University Provost and Harvard University Medical School Professor of Neurobiology): Reward- and fear-based learning
- Marilyn Albert (Johns Hopkins University): Alzheimer's disease
- Ray DePaulo and Kay Redfield Jamison (Johns Hopkins University): Bipolar disorder
- Adam Kaplin (Johns Hopkins University): Depression
- Alysa Doyle (Harvard University): Attention deficit and hyperactivity disorder
- Daniel Weinberger (National Institutes of Health): Schizophrenia
- Seth Grant (Wellcome Trust Sanger Institute): Genomic neuroscience
- Joy Hirsch (Columbia University): Neuroimaging
- Mary Colvard, Laura Maitland, and Caren Gough (Faculty Fellows): Biology and psychology education

In conjunction with concept mapping, we developed an Internet-accessible editing system to meta-tag *G2C* content. The system uses key words, scales, and classifications to define an item's position in the knowledge network. A *Yahoo!* term extractor automatically identifies suggested keywords from any inputted text field. The item's relevance is then rated according to 20 conceptual domains within biological systems, cognitive disorders, and approaches to science. The system also collects a number of basic data fields that we have developed as a collaborator in BiosciEdNet, a National Digital Science Library (NSDL) project headed by the American Association for the Advancement of Science. The NSDL metadata scheme aligns with the other major projects and includes technical specifications, media type, educational uses and context, end-user roles, knowledge taxons, creator information, life cycle, and rights.

We chose autism as the topic for which to develop prototype content and interactive student activities. Of note is an emotion-recognition game that highlights the difficulty many autistic people have in "reading" facial expressions. This engaging activity is framed within the context of current research on the neural and genetic basis of the disorder, including interviews with Trevor Robbins (Cambridge University), Ron McKay (University of Edinburgh), and Dan Geschwind (University of California, Los Angeles). We also



Genes to Cognition (G2C) Online demonstration screen shots featuring autism.

capitalized on the project's February Advisory Panel meeting at the Wellcome Trust Sanger Institute, videotaping interviews and lab demonstrations with collaborators on the *G2C* research team.

In June, we conducted the first evaluation of the prototype site. High school biology and social science students reviewed two entirely different *G2C Online* designs and navigation systems. We were especially interested in their understanding of the purpose of the site and how to move from topic to topic. The student reactions and misperceptions prompted important changes that should improve how they interact with the site and integrate the "big" ideas we hope to get across. This study is the first of a number of keystone evaluations that will guide the development of *G2C Online* and, ultimately, demonstrate its usefulness in modern biology and psychology education.

The project also gained insight from a high-level workshop, *New Horizons in Internet Site Development*, held October 22–25 at the CSHL Banbury Center. Co-chaired by Ed Rover, President of the Dana Foundation, and Marshall Smith, Director of Education at the Hewlett Foundation, the 2.5-day meeting drew together 30 experts and opinion leaders from diverse fields, including cognitive science, neuroscience, network theory, knowledge management, learning theory, and technology convergence. A common theme throughout the meeting was the growing ability of the Internet to connect people in real-time in "communities" of common interest. Among the presenters were Tim Tully (CSHL), Walter Baer (Annenberg Center for Communication), John Jungck (Beloit College), John Kruper (Cardean Learning Group), John Beisty (SAP America), and Katy Börner (Indiana University). A working paper on insights gained from the meeting was developed with the Center for Children and Technology (CCT), with whom we are collaborating to evaluate site development.

New Horizons in Internet Site Development presenters Simon Buckingham (Open University) and John Kruper (Cardean Learning Group) network during session break. Conference organizer John Connolly and Katy Börner (Indiana University) discuss her talk on mapping science.

Record Number of Real and Virtual Visitors in 2006

Annual visitation topped 40,000 in 2006. This included 29,657 students who conducted experiments with DNALC staff (on field trips to the DNALC or at their own schools) and 824 summer campers who spent a week at the DNALC—both record highs. The DNALC has been the beneficiary of a growing demand for science enrichment, precipitated by new teaching standards and the specter of the impending national science achievement test for 6th graders in 2007. More than 60 school systems participated in middle school programs, and younger students comprised a majority of our clientele for academic year field trips and summer workshops. A typical middle school field trip includes a mix of hands-on labs (such as DNA extraction or bacterial transformation), guided tour of *The Genes We Share* exhibit, and virtual labs (such as *The Mystery of Anastasia* and *Otzi: The Iceman Cometh*). As basic genetics and biotechnology labs have moved increasingly to the middle schools, we have encouraged high school faculty to upgrade their instruction. Thus, more than half of high school field trips allowed students to look at their own DNA and to understand how DNA differences (polymorphisms) are used to understand human evolution.

Middle-school students participate in a *World of Enzymes* summer camp.

A grant from the Porter Foundation allowed us to provide field trip scholarships for 1378 middle school students and 569 high school students from underserved schools from Long Island, Queens, Brooklyn, and Manhattan. This included 222 students from the Gateway Institute for Pre-College Education, which provides intensive enrichment to prepare high school students for success in college. The grant also supported 30 disadvantaged students who attended a five-day workshop on forensic biology conducted in cooperation with John Jay College of Criminal Justice, and four students who attended DNA camps at the DNALC.

Saturday DNA! Programs offered 375 parents and children fun opportunities to learn about the latest developments in the biological sciences. The DNALC's education and scientific presented lively two-hour programs, such as "When Dinosaurs Roamed the Earth," "Jellyfish Genes," and "Mapping Your Way Through DNA." Sessions included hands-on DNA experiments, computer bioinformatics, and microscopic observation.

The DNALC's reach was effectively doubled by the activities of four institutions that license our teaching and Internet technology. The DNA Learning Lab at the Singapore Science Centre led the way conducting labs with 22,188 students and providing outreach activities for an additional 14,799 visitors. The DNA Centre at Singapore's National Institute of Education provided in-depth training for 278 precollege teachers. Vienna Open Lab, located in the new Campus Vienna Biocenter complex. began operation in the spring, providing labs for 990 students, training for 13 teachers, and outreach activities for 425 visitors. The South Carolina DNA Learning Center at Clemson University got off to a strong start, reaching 926 students with lab field trips, 86 students in extended summer camps, and 425 public participants.

Visits to DNALC's family of nine Internet sites rose 14% in 2006 to 7 million. *BioServers*, tools for analyzing student DNA differences, registered the largest increase (43%), followed by *DNA Interactive*, commemorating the 50th anniversary of the discovery of the structure of DNA (31%), and *Image Archive on the American Eugenics Movement*, searchable materials on the misuse of genetics in the early 20th century (16%). In January, we launched *Inside Cancer*, a multimedia resource on the molecular and cellular basis of cancer. During the year, it garnered considerable recognition, including selection as finalist in the Pirelli International Awards (life sciences category), *Science* Magazine *Netwatch* (May 12), *Yahoo* "New and Notable Sites" (May 18), and *Adobe* Site of the Day (August 4).

Internet Site	Average Visit Length (in minutes)	Visits in 2006	Change Over 2005
Gene Almanac	9:30	2,299,503	8.96%
DNA from the Beginning	8:48	1,481,110	9.25%
Your Genes, Your Health	8:04	1,115,186	–2.13%
DNA Interactive	8:31	1,266,555	31.26%
Image Archive on the American Eugenics Movement	12:52	331,388	15.71%
BioServers	17:17	228,464	43.48%
Genetic Origins	9:26	150,954	7.58%
Inside Cancer	8:39	120,342	n.a.
All Sites	**10:23**	**7,002,140**	**13.74%**

Insights into Internet Site Use

Internet educators are increasingly called on to provide data about who uses their sites and what impact they have. To answer this call, in November, we administered an e-mail and online survey that provided a glimpse of how the DNALC's *Inside Cancer* and the *Image Archive on the American Eugenics Movement* sites are used by teachers, students, health professionals, and the general public. Surveys were completed by 1515 *Inside Cancer* and 931 *Eugenics Archive* users. (*Inside Cancer* response percentages are listed first and in italics.)

Consistent with studies by Nielson and the National Center for Education Statistics which show that the United States is well "wired," the vast majority of respondents accessed the site via a broadband connection (*88%/*83%)—with most connecting from home (*47%*, 47%), school (*24%*, 28%), or work (*23%*, 21%). Respondents were enthusiastic about the sites, with the vast majority giving good or excellent ratings on rating overall content (*90%*, 90%), content authority (*87%,* 90%), understandability (*87%*, 87%), videos (*86%*), design (*84%,* 87%), and navigation (*81%*, 81%). Nearly all (*98%*, 98%) said that they likely would visit the sites again and would recommend them to others (*95%*, 93%), including to students (*69%*, 68%), teachers (*63%*, 65%), professionals (*36%*, 39%), cancer patients (*24%*), and friends and family (42%).

The majority of respondents were educators (*55%*, 57%), followed by students (*20%*, 23%) and medical or science professionals (*19%*, 12%). Of educators, most reported readily available computer and Internet resources, including presenter computer with video projector (*74%*, 74%) and broadband access (*61%*, 63%), and student computers with broadband access (*71%*, 74%). Most educators had come to the site looking for lesson materials (*76%*, 74%) or links to assign for student readings (*44%*, 39%), and nearly all (*98%*, 95%) said they were likely to continue to use the site in the future to prepare for class or for student assignments. A number of teachers had already used the sites in their classes (*43%*, 56%) impacting the following number of students.

Classroom Use	Student Exposures	
	Inside Cancer	***Eugenics Archive***
Used site for information for preparing a lesson or lecture	13,383	13,720
Presented site content in lecture or seminar	10,855	10,666
Students used site in class or computer lab	8,610	7,886
Assigned students site as homework or independent study	7,288	8,191
Provided link to site from a community resource	5,607	4,078

Most educators had used the sites with secondary (*64%*, 65%) and college (*22%*, 25%) classes, with fewer in middle school or postgraduate classes (*7% each*, 4% each). Most secondary teachers had used the sites in general biology (*64%*, 66%) or Advanced Placement or honors (*49%*, 45%) classes.

Although relatively few high school teachers had used *Inside Cancer* for health education classes (*6%*), a majority of college faculty had used the site with health and allied health classes (*63%*). These results suggest that there is a strong health context for the site but that we will need to work to develop this constituency at the high school level. Relatively few high school teachers had used the *Eugenics Archive* for nonscience classes (9%). More college faculty had used the site for nonscience classes (32%), including history, philosophy, or psychology—illustrating the potential for cross-disciplinary instruction.

Most students had visited the sites for a school assignment or project (*44%,* 67%) or for general interest (*53%,* 31%) or for a school assignment. Most also thought it likely that they would return to the sites as a reference for homework or a project (*49%*, 65%) or to help them understand course materials (*60%,* 49%).

We were particularly interested in gauging site accuracy by way of the responses of historians and medical, legal, and science professionals. Statistical comparisons revealed no significant differences between professionals' evaluations of the sites compared to other demographic groups. The vast majority of professionals gave good or excellent ratings for rated overall content (*89%,* 87%) and content authority (*86%,* 89%) and said that they would use the site in the future (*95%,* 92%). Most professionals intended to use the *Inside Cancer* site for background information (*68%*), to provide a link to a client or patient (*47%*), or as a source of content to present at a meeting or seminar (*40%*). Professionals thought that they were most likely to use *Eugenics Archive* materials for academic research (61%), to prepare for a meeting (59%), or to present at a meeting or seminar (37%).

Cold Spring Harbor Partnership

Since its founding in 1988, the DNALC's interaction with students had been mainly limited to brief exposures during academic year field trips or summer DNA camps. Although we work intensively with student interns, we had for years hoped to implement a "capstone" laboratory course in molecular and genomic biology in conjunction with neighboring Cold Spring Harbor High School (CSHHS). In the spring, we realized this long-held desire when we graduated our first class of 21 high school seniors who participated in the Cold Spring Harbor Partnership. Then, in the fall, we welcomed our second class of Partnership students.

Students observe *C. elegans* as part of the Cold Spring Harbor High School course at the DNALC.

DNALC staff and biology teacher Scott Renart co-teaches the year-long Partnership course on alternating days at CSHHS and the DNALC. The course uses lab experimentation to explore the genetics and genomics of four major biological systems: bacteria, plants, roundworms, and humans. In the bacterial unit, students learn the basics of gene manipulation by making and analyzing recombinant DNA molecules in the bacterium *E. coli*. The plant unit emphasizes concepts in gene structure, including a detailed analysis of newly sequenced genes in rice and an assay for transgenes in genetically modified food. In the human unit, students use their own DNA differences to study genetic variation in human populations and the evolution of sensory receptors. In the final unit, students use the cutting-edge technique of RNAi to study gene function in the nematode *C. elegans*.

The first year's course included two miniprojects in the bacterial and human system. The second year's course places greater emphasis on independent research, providing students opportunities to design and troubleshoot experiments of their own design. This training in critical thinking will prepare the Partnership students for success the business, legal, and social sciences, as well as the biological sciences.

Teacher Professional Development

Professional development activities reached a record number of high school and college faculty; 281 educators attended 13 2- to 5-day workshops on RNAi, plant genomics, bioinformatics, and genetics. Held in six U.S. states and Singapore, these workshops were sponsored by the National Science Foundation (NSF), National Institutes of Health (NIH), Amgen Foundation, Aspen Science Center, Wachovia Bank, and the Singapore Ministry of Education. An additional 220 educators participated in miniworkshops conducted at professional meetings in collaboration with Carolina Biological Supply Company. Topics at miniworkshops included detecting GM foods by PCR, forensic identification of the Romanov family remains, molecular genetics of bitter taste, bioinformatics, and the American eugenics movement.

In July, our flagship *Leadership Symposium* was reinstated with three-year support from the Amgen Foundation. The program drew 23 high school teachers from 16 states, as well as Colombia and Singapore. Originally established in the early 1990s with support from the National Science Foundation (NSF), this three-week long program provides super-order training for teachers who have significant teaching program in genetics or biotechnology. During their stay, *Leadership* participants were immersed in science, living on the main CSHL campus, walking in the footsteps of Nobel Prize winners, and talking informally with high-level participants in the Lab's postgraduate training courses.

The curriculum included experiments in bacteria, plants, roundworms, and humans. Participants had the opportunity to test the DNALC's latest lab methods, in advance oftheir availability at other institutions or from commercial suppliers. These experiments included assaying for mutations in olfactory receptors, analyzing newly discovered genes in rice, and using RNAi to "knock down" genes in the roundworm *C. elegans*. The final week was dedicated to independent study or group projects that included screening supermarket foods for genetic modification, expanding computer-based studies on bioinformatics, constructing web pages, and constructing new reagents for RNAi screens.

With support from the National Science Foundation and the Dana Foundation, ten college and high school faculty took on summer fellowships at Cold Spring Harbor. Six teachers assisted with the development of the new Internet sites *G2C Online* and *Dynamic Gene*; four split time between the DNALC and advanced plant genomics on the main CSHL campus.

The DNALC's professional development programs retained widespread popularity among educators, even while many teacher-training programs experienced difficulty in recruiting faculty participants. As evidence of educator interest, we received more than 240 qualified applications for a total of 152 spaces in six grant-funded summer workshops. Collaborating with historically Black (HBCU) or Hispanic (HACU) institutions enabled us to increase the proportionate attendance of underrepresented minorities; 48% of participants were either Black or Hispanic at workshops conducted at Rust College and North Carolina Agricultural and Technical State University, which compares to 11% at Oklahoma City Community College, City College San Francisco, and New York Institute of Technology. This obser-

vation prompted us to increase our collaboration with HBCU and HACU institutions in three proposals submitted to the NIH and NSF. Ultimately, this initiative will enable us to tackle the ethnographic disparity between groups pursuing careers in science and the general population.

The DNALC has provided the educational outreach components to four NSF-funded research programs led primarily by CSHL faculty. All four educational programs entail development and teacher-training components.

- *Develop a comparative mapping database for cereals*, Lincoln Stein and Doreen Ware (CSHL), We completed a pilot version of the *Dynamic Gene* Internet site, developed a *Dynamic Gene* training curriculum, and disseminated the curriculum in five 1.5-day workshops to 111 high school and college faculty. Teachers were instructed in the use of the educational segments of the *Dynamic Gene* Internet site, as well as in gene annotation using Apollo. Additional workshops will be conducted in 2007 and 2008 for a final total of 16 workshops.
- *Functional analysis of genes in maize*, Marja Timmermans (CSHL) and Mike Scanlon (Cornell University); and *Finishing the sequencing of the rice genome*, Dick McCombie (CSHL). These projects have the objective of expanding the participation of underrepresented minorities in teaching plant genomic biology. Faculty Fellows are selected from minority institutions and spend time in a CSHL research lab as well as at the DNALC, giving them the opportunity to update their research and educational portfolios. In 2006, Dr. Diomede Buzingo (Langston University, Langston, Oklahoma) and Dr. Gokhan Hacisalihoglu (Florida Agricultural & Mechanical University, Tallahassee, Florida) joined us as Faculty Fellows on the maize project. After completing training, the Fellows host a DNALC course at their home institution to introduce local educators to classroom-tailored laboratory and bioinformatics modules. We conducted educator workshops at the home institutions of Dr. Muhammad Mian (Rust College in Holly Springs, Mississippi) and Dr. Mary Smith (North Carolina Agricultural and Technical State University in Greensboro, North Carolina), 2005 Fellows on the rice project. Thirty-eight high school teachers and two-year college faculty participated in these courses. To support local dissemination, each Fellow's institution receives an equipment package, including a thermocycler, centrifuge, UV-lightbox, camera, pipettes and precast gels. Fellows then establish an equipment loan program to provide local educators the physical resources to conduct the plant genomics experiments in their classrooms.
- *Determine the function of protein-coding genes in* Arabidopsis thaliana, David Jackson (CSHL). Although funding for this program expired in 2004, we concluded the educational component of this project with a final workshop in August 2006 at the New York Institute of Technology. Seventeen college educators were introduced to plant genomics laboratory and bioinformatics teaching modules developed during the program.

Watson School of Biological Sciences

Our collaboration with the Watson School of Biological Sciences provides the CSHL graduate students with a unique teaching opportunity. Rather than the traditional training of graduate students as Teaching Assistants, Watson school students complete a spring rotation working with middle and high school students at the DNALC. Over the course of 12 half-day sessions, students work in pairs under the tutelage of seasoned DNALC instructors.

During the first phase of the training, students observe a DNALC instructor deliver a laboratory to a visiting class. Post observation, the students begin to organize a lesson plan, which integrates their own experience within the context of a specific experiment. The second phase is co-teaching, during which each student is responsible for delivering a specific part of the laboratory. The third phase is independent instruction, during which the students work together to present an entire laboratory—under the observation of the DNALC instructor. During each phase, students receive oral and written critiques aimed at strengthening their presentation and class management skills. After repeating this learning process at the middle school and high school levels, the students are required to independently teach an additional three lessons of their choice.

Some students opt to travel to a local school district to deliver instruction to several middle school classes. Although the CSHL graduate students are well versed in molecular biology, few have ever attempted to teach these concepts to young students. We believe that the skills required to deliver a successful lab experience to precollege students—engagement, organization, and time management—are the same skills needed to communicate with any audience.

Staff and Interns

At summer's end, we said goodbye to high school instructor Jeanette Collette, who took a position at Commack High School to teach Regents biology, forensics, and scientific research. During two years at the DNALC, she proved adept in many areas of biology. She had a key role in developing the *Greenomes* plant curriculum, growing specialized *Arabidopsis* and maize plants, assisting with workshop instruction, and working on the companion Internet site. Through thick and thin, she sang her way through the labs and hallways. We will miss her enthusiasm and sunny personality.

In December, computer programmer Adrian Arva left to pursue a Master's degree in Business Administration at the prestigious Institute for Management Development (IMD) in Lausanne, Switzerland. A native of Romania, in 2001, Adrian responded to job ad on the DNALC Internet, passed a phone interview with CSHL Professor Lincoln Stein, and was hired site unseen. We could not have been luckier to find such a brilliant programmer during the height of the Internet bubble. His masterful programming, with added insight from his M.D. background, provided the backbone of the DNALC's Internet venture during a time of rapid expansion.

So taken were we with Adrian's performance that we immediately hired another Romanian, Cornel Ghiban, to take his place at year's end. After studying computer science and engineering at Technical "Gheorghe Asachi" University in Iasi, Cornel designed software for small financial clients. He also did contract work for the DNALC, developing backend registration, database, and webserver functions for several of our Internet sites.

Cornel Ghiban (left) and Malissa Hewitt.

During the year, we welcomed Malissa Hewitt back to the instructional staff. Malissa started at the DNALC as a laboratory instructor in 1994, becoming the first full-time employee devoted to middle school instruction. In 1997, she stepped up to manage the middle school program and then left in 1998 to become a full-time mom. Her deep understanding of the history of the DNALC, her strong connections to the local community, and her love of children make Malissa's return especially valuable.

Student interns continued to provide key support for our activities. The sequencing service continued to grow with the help of college interns Alina Duvall (Hofstra University), Jennifer Aiello (C.W. Post), and Alexandra Sloane (Loyola College, Maryland). Joining the program in 2006 were Yusuf Anwar (Syosset), Carissa Maurin (Lynbrook), Seth Schortz (Half Hollow Hills), Andrea Tufano (Syosset), and Brittany Woods (Cold Spring Harbor High School). The new members joined returning interns Matt Giambrone (Walt Whitman), Matthew Levy (Kings Park), Tama Mizuno (Northport), Ronnie Morasse (Plainedge), Nick Wilken (Kings Park) and Janice Yong (Kings Park).

While most interns perform general preparation for lab experiments, Brittany Woods and Carissa Maurin worked with Bruce Nash to develop and maintain *C. elegans* stocks used in our NSF program. Kyle Shybunko, a research student at Ward Melville, worked with Greg Chin to submit a project on human olfactory receptors to the Siemens competition. Yusuf Anwar's research on tissue development at Stony Brook University won him a Special Congressional Recognition Award and placed him as a semifinalist in the Siemens Competition.

Several interns returned from college to assist with summer workshops: Benjamin Blonde (Amherst College), Bryn Donovan (University of Delaware), Kimberly Izzo (Indiana University), and Marie Mizuno (SUNY Binghamton). In August, Joseph Hakoopian (Walt Whitman) left for his freshman year at Cornell University; Margarita Varer (Huntington) left for SUNY Binghamton, and Brittany Woods (Cold Spring Harbor) left for Boston College.

David A. Micklos
Executive Director

2006 Workshops, Meetings, and Collaborations

January 9–11	NSF *Gramene* Faculty Fellowship: Robert Wheeler, Pine Creek High School, Colorado Springs, Colorado
January 11	Site visit and museum tour for the incoming class of the Watson School of Biological Sciences, Cold Spring Harbor Laboratory (CSHL)
January 21	*Saturday DNA!,* "When Dinosaurs Roamed the Earth" and "Teenage Mutant Critters," DNALC
January 30	Site visit by Lisa Blair, Director, Wendi O'Rand, Educator, and Denise Richard, Administrative Assistant, Abernathy Science Education Center, Girard, Kansas
February 1–2	BiosciEdNet (BEN) Collaborators Meeting, Washington, D.C.
February 6–10	*G2C Online* Advisory Meeting, Cambridge, United Kingdom
February 11	CSI Workshop for Children Associated with Hermansky Purdlak Syndrome Foundation Annual Meeting
February 11	*Saturday DNA!,* "2006: A Science Odyssey" and "One Fish, Two Fish, Green Fish, Glofish!," DNALC
February 15	Site visit by Norman Kelker, Senior Vice President, Enzo Life Sciences, Farmingdale, New York
February 17	Annual American Association for the Advancement of Science Meeting, St. Louis, Missouri
February 24–25	Aspen Science Center Teacher Training Workshop, Aspen, Colorado
March 1	Site visit by Rogert Mummert, freelance writer, *New York Times*, New York, New York
March 1	Site visit by Theodore Roosevelt American Inn of Court, St. John's University, School of Law, Nassau County, New York
March 1	Site visit by Sharon Grosser, Executive Director, Roslyn Savings Foundation, Roslyn, New York
March 1	Site visit by Michio Ichimura, Kyowa Hakko Chemical Co., Ltd., Japan
March 2	Site visit by Patrick Foye, President, and Teri Zielenski, Senior Vice President, United Way of Long Island
March 8	Site visit by George Harrison, Harrison Family Foundation, John S. Grace, President, Sterling Grace Capital Management, and Lola N. Grace, Managing Director, Sterling Grace Capital Management, and Vice Chairman CSHL Board of Trustees
March 11	*Saturday DNA!* Seminars, "Wanted: Dead or Alive?" and "Little Fly, Why Did You End Up a Guy?," DNALC
March 15	Site visit by David Skuse, Institute of Child Health, London, United Kingdom
March 19–21	*RNAi* Advisory Board Meeting, DNALC
March 21	West Side School Lecture, "Why All the Fuss about Bird Flu?," Lee Henry, CSHL
March 22	Site visit to William Randolph Hearst Foundation, New York, New York
March 23	Annual *Cancer Biomedical Informatics Grid* (caBIG) Meeting, Bethesda, Maryland
April 4	*Great Moments in DNA Science Honors Student Seminar,* Hollis Cline, CSHL, "Seeing is Believing: Imaging Brain Development in the Intact Animal," CSHL
April 6–8	National Science Teachers Association National Meeting, Anaheim, California
April 11	*Great Moments in DNA Science Honors Student Seminar*, Grigori Enikolopov, CSHL, "Teaching an Old Dog New Tricks? Stem Cells in the Adult Brain," CSHL
April 14	Site visit by Bob Wheeler, Pine Creek High School, Colorado Springs, Colorado; and Brenda Dempsey, George Washington High School, Denver, Colorado
April 18	Site visit by Lillian DeRosa and family, friends of Leo Guthart, owner of Topspin Partners, LP, Roslyn Heights, New York
April 19	Site visit by Lynda Parmely, Program Officer, Horace Hagedorn Foundation, Jericho, New York
April 20	Site visit by Joanne Duhl, Goldman Sachs Foundation, New York, New York
April 20	Site visit by Edward Atwood, Vice President Multimedia Services, Cablevision, Bethpage, New York
April 21	Site visit by Marcia Bishop, Associate Director, and Ronald Sjoerdsma, Fellow, Van Andel Education Institute, Grand Rapids, Michigan
April 21	Site visit to Davidoff Malito & Hutcher LLP, New York, New York
April 22	*Saturday DNA!* Seminars, "Jellyfish Genes" and "Mapping Your Way Through DNA," DNALC
April 24	Site visit by Rosemary Nicholls, Senior Vice President, Teachers Federal Credit Union, Farmingville, New York
April 24	West Side School Lecture, "Why Do We Have Two Copies of Every Gene?," Alea Mills, CSHL
April 26	Site visit to the Harvard Club of New York City for National Institute of Social Sciences Little Think Tank Luncheon, New York
May 1	*Great Moments in DNA Science Honor Student Seminar*, Anthony Leotta, CSHL, "Finding Cancer Genes Using Microarrays," CSHL
May 1	Site visit to New York Hall of Science for Science Task Force Meeting, Queens, New York
May 5	Site visit to New York City Department of Education with Julia Rankin, Director of Science, New York, New York
May 7	Dedication Ceremony for the Marc David Chernoff Bioinformatics Laboratory, DNALC
May 10–11	Site visit to Carolina Biological Supply Company, Burlington, North Carolina
May 11	Site visit by Landon and Lavinia Clay, Directors, and Jim Carlson, President, Clay Mathematics Institute, Cambridge, Massachusetts
May 13	Site visit by Pamela Omidyar (wife of Pierre Omidyar, Chairman and founder of eBay) and family
May 16	Site visit by Harouna Ba, Senior Research Associate, Center for Children and Technology, New York, New York
May 16	Site visit to North Shore-Long Island Jewish Health System, Feinstein Institute for Medical Research, for talk by Lawrence Scherr, Lake Success, New York
May 18	Site visit by Jason Morris, Assistant Professor of Biology, Fordham University, New York, New York
May 18–19	Site visit to the Life Learning Center, Bologna, Italy
May 20	*Saturday DNA!* Seminars, "Bug Zappers" and "What's a Stem Cell Supposed to Do?," DNALC

May 23	Dedication of Vienna Open Lab, Vienna, Austria
June 5–9	NSF *Frontiers in Genomics: RNA Interference and Genome Annotation* Workshop, with Charlotte Mulvihill, Oklahoma City Community College, Oklahoma City, Oklahoma
June 6	*Cold Spring Harbor Partnership Program* Graduation Ceremony: Tom Dolan, Principal, Scott Renart, science teacher, and 120 students and parents, Cold Spring Harbor High School, New York
June 8	Site visit by Mahlon Hoagland, author, and Ken Gleason, science museum consultant
June 10	*Saturday DNA!* Seminars, "Fruit Fly Island" and "Conquering a Genetic Disease," DNALC
June 12–16	NSF *Plant Molecular Genetics and Genomics* Workshop, with NSF Minority Fellow Muhammad Mian, Holly Springs, Mississippi
June 13	Site visit by Kidgie Williams, diplomats, and family members of United Nations representatives, Hospitality Committee for United Nations Delegations, Inc., New York, New York
June 14	Site visit by Robert Diller, Director of Sales and Marketing, and Zock Zamanian, Brinkmann Instruments, Inc./Eppendorf AG, Westbury, NY
June 19	Site visit by Arthur Rosoff and Henry Bachman, Long Island Museum of Science & Technology, Garden City, New York
June 22	Site visit by Kathryn Silva and Ralph Brave, University of California, Sacramento
June 19–23	NSF *Plant Molecular Genetics and Genomics* Workshop, with NSF Minority Fellow Mary Smith, North Carolina Agricultural and Technical State University, Greensboro
June 26–30	Site visit by Florence Francis, Chief Scientific Officer of the Learning Lab, Singapore Science Center, Singapore
June 26–30	*Fun with DNA* Workshop, DNALC *DNA Science* Workshop, DNALC *World of Enzymes* Workshop, DNALC *Fun with DNA* Workshop, DNALC *West*
June 26–30	NSF *Frontiers in Genomics: RNA Interference and Genome Annotation* Workshop, with Elaine Johnson, Bio-Link, City College, San Francisco, California
June 26–30	*Bioinformatics*–In Silico *Biology* Workshop, California State University, Dominguez Hills: LA Biomed, Torrance, California
June 29	New York City Department of Education Advisory Board on Biotechnology Education, American Museum of Natural History, New York, New York
July 3–7	*Fun with DNA* Workshop, DNALC *Green Genes* Workshop, DNALC *DNA Science* Workshop, DNALC *Green Genes* Workshop, DNALC *West*
July 3–7	Aspen Science Center Workshops: *Fun with DNA; World of Enzymes; PCR & Genomic Biology*, Aspen, Colorado
July 4	Aspen Science Center Board of Trustees Meeting, Aspen, Colorado
July 8–23	USDA *Gramene* Faculty Fellowship: Charlie Gutierrez, John H. Reagen High School, Austin, Texas
July 9–21	NSF Minority Faculty Fellowship: Gokhan Hacisalihoglu, Florida Agricultural & Mechanical University, Tallahassee, Florida
July 9–30	Teacher Training at the DNALC: Lui Shea Nee Shirley, Victoria Junior College; Wee Sock Chin, Hua Yi Secondary School; and Petrina Then Yan Ting, Singapore Science Center, Singapore
July 10	Site visit by Josep Prous, David Prous, and Miriam Bayes, Prous Science, Barcelona, Spain
July 10–14	*Genetic Horizons* Workshop, DNALC *World of Enzymes* Workshop, DNALC *DNA Science* Workshop, DNALC *West*
July 10–28	Amgen *Leadership Symposium*, DNALC
July 17–21	Site visit by Karin Garber MAS, Vienna Open Lab–Dialog Gentechnik, Vienna, Austria
July 17–21	*Fun with DNA*, Workshop, DNALC *Human Genomics* Workshop, DNALC *Fun with DNA*, Workshop, DNALC *West*
July 21	Site visit by Daryl Ogden, Executive Director, Project GRAD of Long Island, Roosevelt, New York, and Teresa Kemp Zielenski, Senior Vice President of Community Impact, and Kristine Donnelly, United Way of Long Island, Deer Park, New York
July 24–28	*World of Enzymes* Workshop, DNALC *Green Genes* Workshop, DNALC
July 24–28	Site visit by *G2C Online* Fellows Caren Gough, Education Consultant, and Laura Maitland, AP Psychology consultant
July 25–26	Site visit by *G2C Online* consultant Joe Novack, Institute of Human and Machine Cognition (IHMC), Pensacola, Florida
July 26–August 5	NSF *Gramene* Faculty Fellowship: Debra Burhans, Canisius College, Buffalo, New York, and Robert Wheeler, Pine Creek High School, Colorado Springs, Colorado
July 26–August 5	Site visit by Suzanne Leeds, member Cold Spring Harbor High School Improvement Team & DNALC Committee
July 31–August 4	*Fun with DNA* Workshop, DNALC *Genetic Horizons* Workshop, DNALC

	DNA Science Workshop, DNALC
	World of Enzymes Workshop, DNALC *West*
July 31–August 4	*Forensics and Human Genomics* Workshop, with Lawrence Kobilinsky, John Jay College of Criminal Justice Manhattan, New York
August 1	Site visit by Dee Rawsthorne, John Innes Centre, Norwich, United Kingdom
August 2	Site visit by Lori Bressler, Cold Spring Harbor School Board, Cold Spring Harbor, New York
August 2	Site visit by Ida Cole, former Microsoft executive and philanthropist
August 7–11	*World of Enzymes* Workshop, DNALC
	Green Genes Workshop, DNALC
	DNA Science Workshop, DNALC
	NSF *Plant Molecular Biology, Genomics and Bioinformatics* Workshop, New York Institute of Technology, New York, New York
	Forensics and Human Genomics Workshop, with Lawrence Kobilinsky, John Jay College of Criminal Justice, New York, New York
August 6–19	NSF Minority Faculty Fellow Diomede Buzingo, Langston University, Langston, Oklahoma
August 14–18	*Fun with DNA* Workshop, DNALC
	Genetic Horizons Workshop, DNALC
	DNA Science Workshop, DNALC
	*DNA Science*Workshop, DNALC *West*
August 14–18	NSF *Frontiers in Genomics: RNA Interference and Genome Annotation* Workshop, New York Institute of Technology, New York, New York
August 15	Site visit by Lisa Mars, Vice President and Director for Digital Schoolhouse Foundation, Islandia, and Teresa Kemp Zielenski, Senior Vice President of Community Impact, and Kristine Donnelly, United Way of Long Island, Deer Park, New York
August 16	Site visit by Eric Eversley, Superintendent, Freeport School District, and Teresa Kemp Zielenski, Senior Vice President of Community Impact, and Kristine Donnelly, United Way of Long Island, Deer Park, New York
August 21	Site visit by Ed Rover, President, Burt Mirsky, Vice President, Finance, and Abigal Slovonic, Program Officer, Dana Foundation; and James Watson, Chancellor, CSHL
August 21–25	Site visit by Michael Marshall, Wellcome Trust Sanger Institute, Cambridge, United Kingdom
August 21–25	*Fun with DNA* Workshop, DNALC
	World of Enzymes Workshop, DNALC
	Green Genes Workshop, DNALC
	Human Genomics Workshop, DNALC *West*
August 21–25	New York City Department of Education Educator Workshop, *DNA Investigations*, New York, New York
August 25	Site visit by Fumitaka Akeda, President, and Lee Schuett, Executive Vice President, Nikon Instruments, Melville, New York
August 28–	*Genetic Horizons* Workshop, DNALC
September 1	*World of Enzymes* Workshop, DNALC
	DNA Science, DNALC
	Plant Genomics Workshop, DNALC *West*
September 7	*Esquire* Magazine photo shoot with James Watson, Chancellor, CSHL
September 8	Site visit by Richard Quest, CNN's London-based anchor and correspondent, London, England
September 20	Site visit by Susan Berland, Town of Huntington Councilwoman, Huntington, New York
September 21	Site visit by Kathy Vandiver, Director of Community Outreach and Education, Center for Environmental Health Sciences, MIT Museum, Cambridge, Massachusetts
September 21	Site visit by Aledandra Manaia, European Molecular Biology Laboratory (EMBL), Heidelberg, Germany
September 21–25	NSF *Gramene* Faculty Fellowship: Robert Wheeler, Pine Creek High School, Colorado Springs, Colorado
September 22–25	NSF *Gramene* Faculty Fellowship: Debra Burhans, Canisius College, Buffalo, New York
September 21	Site visit by Marianne Carolton, Director of Internal Communications, and James Cuniglio, Communications Coordinator, Arrow Electronics, Melville, New York
September 27	Site visit by Edward Atwood, Vice President Multimedia Services, Cablevision, Bethpage, New York
September 28	Site visit to Cold Spring Harbor High School for meeting with Jay Matuk, Principal, and Andy Clouser, Science Department Chairman, Cold Spring Harbor, New York
October 2–4	Novartis Exploratory Clinical Development Group, RNA and Cancer Biology, Banbury Center and DNALC
October 5	Site visit by Daryl Ogden, Robert Troiano, Executive Director, and Kim Arias, Director of Programs, *Project Grad* Long Island, Roosevelt, New York; and Connie Clark, Superintendent, and Robert Root, Assistant Superintendent for Curriculum Instruction and Personnel, Westbury School District, Westbury, New York
October 11–13	National Association of Biology Teachers National Meeting, Albuquerque, New Mexico
October 14	*Saturday DNA!* Seminars, "Genes and Generations" and "Spotlight on Cell Division," DNALC
October 16	Site visit by Eric Krasnoff, President, and Saied Tousi, Senior Vice President of Global Infrastructure, Pall Corporation, East Hills, New York
October 18	Site visit by Lori Bressler, President, Cold Spring Harbor Board of Education; and Judith Wilansky, Cold Spring Harbor Adult Education Program, Cold Spring Harbor, New York
October 22–24	*New Horizons in Internet Site Development* Meeting, CSHL Banbury Center

October 24	Site visit by Bob Malito, Garden City, New York, and Arthur Goldstein, New York, New York, Law Firm Davidoff, Malito & Hutcher
October 25–26	NY Enhancing Collaborative Leadership for Improved Performance in Science Education (ECLIPSE) Leadership Conference, Albany, New York
November 2–4	National Science Teachers Association Regional Meeting, Baltimore, Maryland
November 6	Science Teachers Association of New York State Conference, Ellenville, New York
November 8	Site visit by 30 members of the Princeton Club, New York, New York
November 8	Site visit by Kirk Kordeleski, President and Chief Executive Officer, and Linda Arymn, Vice President Business Development, Bethpage Federal Credit Union, Bethpage, New York
November 8	Site visit to York College, Dr. Linda Barley, Acting Provost, DNA Lab, New York, New York
November 13–23	Singapore Teacher Training, Singapore
November 14	Excellence in Science Award Annual Reception for the American Association of University Women, Huntington Branch, Huntington, New York
November 15	*FIRST (For Inspiration and Recognition of Science and Technology)* Lego Robotics Group, Long Island, New York
November 18	*Saturday DNA!* Seminars, "The Iceman Cometh" and "Heart and Sole: Studying Heart Development in Fish," DNALC
November 22–23	MOE-NIE-STAS International Science Education Conference, Singapore
November 25–December 9	Teacher Training at the DNALC: Rashidah bte Yahya, Marsiling Primary School; Ginger Tay Leng See, Telok Kurau Primary School; Han Tui Kin, Montfort Junior School; and Pok Sat Yoong, St. Hilda's Primary School
November 28	Site visit by Congressman Bud Cramer, Alabama's 5th Congressional District, U.S. House of Representatives, Alabama
November 30	Site Visit by Matthias Haury, European Molecular Biological Laboratory, Heidelberg, Germany
December 7–8	National Science Teachers Association Regional Meeting, Salt Lake City, Utah
December 8	Site visit and field trip by Minnetonka High School students and teachers, Minnetonka, Minnesota
December 8	Site visit by Manny Arias, High School Principal, and Darnel Powell, Middle School Principal, Westbury School District, New York
December 9	*Saturday DNA!* Seminars, "As the Worm Turns" and "Finding Novel Genes with Degenerate PCR," DNALC
December 11	Site visit by Hans Ullrich, freelance writer, United Kingdom
December 15	Site visit by Bettie Steinberg, Chief Scientific Officer, and Kirk Manogue, Director of Technology Transfer, Feinstein Institute for Medical Research, NS-LIJ Health Systems, Lake Success, New York
December 28	Site visit by *G2C Online* Fellows Caren Gough, Education Consultant; and Laura Maitland, Advanced Placement Psychology consultant

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Sites of Major Faculty Workshops 1985–2006

Key: *Middle School* High School **College**

ALABAMA	University of Alabama, Tuscaloosa	1987–1990
ALASKA	University of Alaska, Fairbanks	1996
ARIZONA	Tuba City High School	1988
ARKANSAS	Henderson State University, Arkadelphia	1992
CALIFORNIA	**California State University, Fullerton**	**2000**
	Canada College, Redwood City	1997
	City College of San Francisco	2006
	Contra Costa County Office of Education, Pleasant Hill	2002
	Foothill College, Los Altos Hills	**1997**
	Harbor-UCLA Research & Education Institute, Torrance	2003
	Los Angeles Biomedical Research Institute (LA Biomed), Torrance	**2006**
	Laney College, Oakland	1999
	Lutheran University, Thousand Oaks	1999
	Pierce College, Los Angeles	**1998**
	Salk Institute for Biological Studies, La Jolla	2001
	San Francisco State University	**1991**
	San Jose State University	**2005**
	University of California, Davis	1986
	University of California, Northridge	**1993**
COLORADO	Aspen Science Center	2006
	Colorado College, Colorado Springs	1994
	United States Air Force Academy, Colorado Springs	**1995**
	University of Colorado, Denver	1998
CONNECTICUT	Choate Rosemary Hall, Wallingford	1987

FLORIDA	North Miami Beach Senior High School	1991
	University of Western Florida, Pensacola	1991
	Armwood Senior High School, Tampa	1991
	University of Miami School of Medicine	2000
GEORGIA	Fernbank Science Center, Atlanta	1989
	Morehouse College, Atlanta	**1991,1996**
	Morehouse College, Atlanta	1997
HAWAII	Kamehameha Secondary School, Honolulu	1990
ILLINOIS	Argonne National Laboratory	1986,1987
	University of Chicago	**1992, 1997**
INDIANA	Butler University, Indianapolis	1987
IDAHO	University of Idaho, Moscow	1994
IOWA	Drake University, Des Moines	1987
KANSAS	University of Kansas, Lawrence	1995
KENTUCKY	Murray State University	1988
	University of Kentucky, Lexington	1992
	Western Kentucky University, Bowling Green	1992
LOUISIANA	Jefferson Parish Public Schools, Harvey	1990
	John McDonogh High School, New Orleans	1993
MAINE	Bates College, Lewiston	1995
	Foundation for Blood Research, Scarborough	2002
MARYLAND	Annapolis Senior High School	1989
	Frederick Cancer Research Center, Frederick	1995
	McDonogh School, Baltimore	1988
	Montgomery County Public Schools	1990–1992
	St. John's College, Annapolis	*1991*
	University of Maryland, School of Medicine, Baltimore	**1999**
	National Center for Biotechnology Information, Bethesda	2002
MASSACHUSETTS	Beverly High School	1986
	Biogen, Cambridge	2002
	Boston University	**1994,1996**
	CityLab, Boston University School of Medicine	1997
	Dover-Sherborn High School, Dover	1989
	Randolph High School	1988
	Winsor School, Boston	1987
	Whitehead Institute for Biomedical Research, Cambridge	2002
MICHIGAN	Athens High School, Troy	1989
MINNESOTA	University of Minnesota St. Paul, St. Paul	2005
MISSISSIPPI	Mississippi School for Math & Science, Columbus	1990, 1991
	Rust College, Holly Springs	2006
MISSOURI	Stowers Institute for Medical Research, Kansas City	2002
	Washington University, St. Louis	1989
	Washington University, St. Louis	**1997**
NEW HAMPSHIRE	**New Hampshire Community Technical College, Portsmouth**	**1999**
	St. Paul's School, Concord	1986, 1987
NEVADA	University of Nevada, Reno	1992
NEW JERSEY	Coriell Institute for Medical Research, Camden	2003
NEW YORK	Albany High School	1987
	Bronx High School of Science	1987
	Columbia University, New York	**1993**
	Cold Spring Harbor High School	1985, 1987
	Cornell University, Ithaca	**2005**
	DeWitt Middle School, Ithaca	*1991, 1993*
	DNA Learning Center	1988–1995, 2001–04, 2006
	DNA Learning Center	**1990, 1992, 1995, 2000**
	DNA Learning Center	*1990–1992*
	DNA Learning Center *West*	2005
	Fostertown School, Newburgh	*1991*
	Huntington High School	1986
	Irvington High School	1986
	Junior High School 263, Brooklyn	*1991*
	Lindenhurst Junior High School	*1991*
	Mt. Sinai School of Medicine, New York	1997
	New York Institute of Technology, New York	2006
	New York Institute of Technology, New York	**2006**
	Orchard Park Junior High School	*1991*
	Plainview-Old Bethpage Middle School	*1991*
	The Rockefeller University, New York	2003

NEW YORK, *continued*	State University of New York, Purchase	1989
	State University of New York, Stony Brook	1987–1990
	Stuyvesant High School, New York	1998–1999
	Titusville Middle School, Poughkeepsie	*1991, 1993*
	Trudeau Institute, Lake Saranac	2001
	Union College, Schenectady	2004
	U.S. Military Academy, West Point	**1996**
	Wheatley School, Old Westbury	1985
NORTH CAROLINA	CIIT Center for Health Research, Triangle Park	2003
	North Carolina Agricultural & Technical State University, Greensboro	2006
	North Carolina School of Science, Durham	1987
OHIO	Case Western Reserve University, Cleveland	1990
	Cleveland Clinic	1987
	North Westerville High School	1990
OKLAHOMA	**Oklahoma City Community College**	**2000**
	Oklahoma City Community College	2006
	Oklahoma Medical Research Foundation, Oklahoma City	2001
	Oklahoma School of Science and Math, Oklahoma City	1994
OREGON	Kaiser Permanente-Center for Health Research, Portland	2003
PENNSYLVANIA	Duquesne University, Pittsburgh	1988
	Germantown Academy	1988
SOUTH CAROLINA	**Clemson University, Clemson**	**2004**
	Medical University of South Carolina, Charleston	1988
	University of South Carolina, Columbia	**1988**
TEXAS	Austin Community College-Rio Grande Campus	2000
	J.J. Pearce High School, Richardson	1990
	Langham Creek High School, Houston	1991
	Southwest Foundation for Biomedical Research, San Antonio	2002
	Taft High School, San Antonio	1991
	Trinity University, San Antonio	**1994**
	University of Texas, Austin	**1999, 2004**
UTAH	University of Utah, Salt Lake City	1993
	University of Utah, Salt Lake City	**1998, 2000**
VERMONT	University of Vermont, Burlington	1989
VIRGINIA	Eastern Mennonite University, Harrisonburg	1996
	Jefferson School of Science, Alexandria	1987
	Mathematics and Science Center, Richmond	1990
	Mills Godwin Specialty Center, Richmond	1998
	Virginia Polytechnic Institute and State University, Blacksburg	**2005**
WASHINGTON	Fred Hutchinson Cancer Research Center, Seattle	1999, 2001
	University of Washington, Seattle	**1993, 1998**
WASHINGTON, D.C	**Howard University**	**1992, 1996**
WEST VIRGINIA	Bethany College	1989
WISCONSIN	Blood Center of Southeastern Wisconsin, Milwaukee	2003
	Madison Area Technical College	**1999**
	Marquette University, Milwaukee	1986, 1987
	University of Wisconsin, Madison	1988, 1989
	University of Wisconsin, Madison	**2004**
WYOMING	University of Wyoming, Laramie	1991

AUSTRALIA	Walter and Eliza Hall Institute and University of Melbourne	1996
CANADA	Red River Community College, Winnipeg, Manitoba	1989
ITALY	Porto Conte Research and Training Laboratories, Alghero	1993
	International Institute of Genetics and Biophysics, Naples	1996
PANAMA	**University of Panama, Panama City**	**1994**
PUERTO RICO	University of Puerto Rico, Mayaguez	1992
	University of Puerto Rico, Mayaguez	**1992**
	University of Puerto Rico, Rio Piedras	**1993**
	University of Puerto Rico, Rio Piedras	1994
RUSSIA	Shemyakin Institute of Bioorganic Chemistry, Moscow	1991
SINGAPORE	National Institute of Education	2001–2005
SWEDEN	Kristineberg Marine Research Station, Fiskebackskil	1995
	Uppsala University, Uppsala	2000

DOLAN DNA LEARNING CENTER GRANTS

Grantor	Program	Duration of Grant	2006 Funding+
FEDERAL GRANTS			
AAAS/NSF	BiosciEdNet (BEN) Collaborative Cycle 3	10/05-9/07	$ 60,958
Cornell University/NSF	Functional Analysis of Genes Involved in Meristem Organization and Leaf Initiation	1/06-8/07	33,559
National Science Foundation	Developing and Disseminating New Laboratories on Plant Molecular Genetics and Genomics	2/05-1/07	37,345
National Science Foundation	Developing and Disseminating New Laboratories in RNAi and Functional Genomics	6/05-12/06	153,518
National Science Foundation	VCA:Finishing the Rice Genome	9/04-8/07	68,042
National Science Foundation	VCA: Gramene: A Platform for Comparative Genomics	12/05-11/07	112,411
Washington University/NSF	Sequencing the Maize Genome	11/05-10/07	17,501
USDA	Systematic Determination of the Gene Set	2/05-1/07	14,611
Virginia Tech/NIH	Partnership for Research and Education in Plants	9/04-8/06	7,694
Washington University/NSF	Sequencing the Maize Genome	11/05-10/07	17,501
NONFEDERAL GRANTS			
Amgen Foundation	Amgen *Leadership Symposium*	4/05-3/08	$ 85,925
Carolina Biological Supply Company	Research support	2006	75,000
Clemson University	License, training, and development	2006	50,000
Dana Foundation	*Genes to Cognition (G2C) Online*: A Network-driven Internet Site on Modern Brain Research	10/05-9/07	235,824
Dialog Gentechnik	License, training and development	2006	24,950
Goldman Sachs Foundation	Planning grant	2006	50,000
Hewlett Foundation	*Genes to Cognition (G2C) Online*	10/05-10/08	114,451
North Shore-LIJ Health System	DNALC *West* support	2006	50,000
Porter Foundation	Underrepresented Communities Program	2006	30,000

The following schools each awarded a grant of $1,000 or more for the *Curriculum Study* Program:

Bellmore – Merrick Central High School District	$1,250	Locust Valley Central School District	$1,250
Bethpage Union Free School District	1,250	Long Beach City School District	2,500
Commack Union Free School District	2,500	Massapequa Union Free School District	2,500
Elwood Union Free School District	1,250	North Shore Hebrew Academy	2,500
Fordham Preparatory School	1,250	Oceanside Union Free School District	1,250
Friends Academy	1,250	Plainedge Union Free School District	1,250
Garden City Union Free School District	1,250	Plainview-Old Bethpage Central School District	1,250
Harborfields Central School District	1,250	Portledge School	1,250
Herricks Union Free School District	1,250	Port Washington Union Free School District	1,250
Huntington Union Free School District	1,750	Roslyn Union Free School District	1,250
Island Trees Union Free School District	1,250	Sachem Central School District	1,250
Jericho Union Free School District	1,250	South Huntington Union Free School District	2,500
Lawrence Union Free School District	1,250	Yeshiva University High School for Girls	1,250
Levittown Union Free School District	1,250		

The following schools each awarded a grant of $1,000 or more for the *Genetics as a Model for Whole Learning* Program:

Bayshore Union Free School District	$5,460	Lawrence Union Free School District	7,800
Bellmore Union Free School District	3,400	Locust Valley Central School District	8187
Bellmore-Merrick Central School District	21,000	Mamaroneck Union Free School District	6,400
Brandeis School	1,850	Merrick Union Free School District	1,200
Commack Union Free School District	5,100	North Bellmore Union Free School District	1,750
East Meadow Union Free School District	1,975	Old Westbury School of the Holy Child	4,950
Elwood Union Free School District	5,120	Oyster Bay – East Norwich Central School District	2,267
Farmingdale Union Free School District	1,600	Plainview – Old Bethpage Central School District	3,469
Floral Park – Bellerose Union Free School District	5,800	Port Washington Union Free School District	10,400
Friends Academy	2,550	Rockville Centre Union Free School District	3,300
Garden City Union Free School District	10,845	St. Dominic Elementary School	3,900
Great Neck Union Free School District	23,792	St. Edward the Confessor School	1,820
Greenvale School	1,587	St. Mary's Elementary School	1,850
Half Hollow Hills Central School District	6,300	Syosset Union Free School District	30,175
Huntington Union Free School District	5,800	Three Village Central School District	3,025
Jericho Union Free School District	9,500	Uniondale Union Free School District	1,200

+ Includes direct and indirect costs

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