Dolan DNA Learning Center

Annual Report 2003

Preparing students and families to thrive in the gene age.

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The sequencing of the human genome, and the genomes of other model organisms, largely has been justified on predicted benefits to human health and agricultural productivity. Beyond these practical objectives is the larger goal of unifying diverse biological disciplines at the molecular level. In the genome age, biologists of all persuasions must learn to grapple with large-scale data sets—and become adept at moving between biological sequence, structure, function, and systematics.

Evolution has been called the only organizing theory in biology, and the National Science Education Standards specifically acknowledge that molecular and evolutionary biology are among the "small number of general principles that can serve as the basis for teachers and students to develop further understanding of biology." Now, the new discipline of comparative genomics offers a natural bridge between molecular and evolutionary biology. By working first-hand with genome data, students can gain a deeper understanding of evolutionary processes, the use of model systems in biology, and the close genetic relationships that exist between seemingly diverse organisms. Students may be rewarded with new and sometimes surprising insights into species relatedness, such as the recent demonstration that humans share a significant number of genes with corals!

Genomic sequences from hundreds of organisms are available to anybody with an Internet connection—as are bioinformatics tools that allow one to explore sequence data, predict the presence of genes, and compare features shared between different organisms. These freely available resources hold out the great promise of making modern biology an egalitarian pursuit open to virtually any biologist or student with a question to ask. Indeed, for the first time in the history of biology, novices can work with the same information, at the same time, and with the same tools as research scientists.

Although biological sequences and bioinformatics tools may be free, there are significant barriers to their widespread use by bioinformatics novices, including mid-career researchers, junior faculty, and students. There is a bewildering array of tools for analyzing sequence information, each with particular strengths and weaknesses. The larger "portal" sites may host a dozen or more tools and databases. The "nested" construction of these Internet sites often means that a particular tool or function is buried under several layers of organization. Effective use of many tools also requires the user to keep track of, and move between, several open browser windows. Most database and tool sites are starkly utilitarian, making few concessions to design or ease of use. Thus, one of the greatest challenges of the genome era is to get sequence data and tools into the hands of a broader base of biologists and to directly involve students in genome bioinformatics. This will require the creation of more intuitive, visually pleasing computer tools that engage novices and allow them to quickly learn the rudiments of genome browsing and sequence analysis.

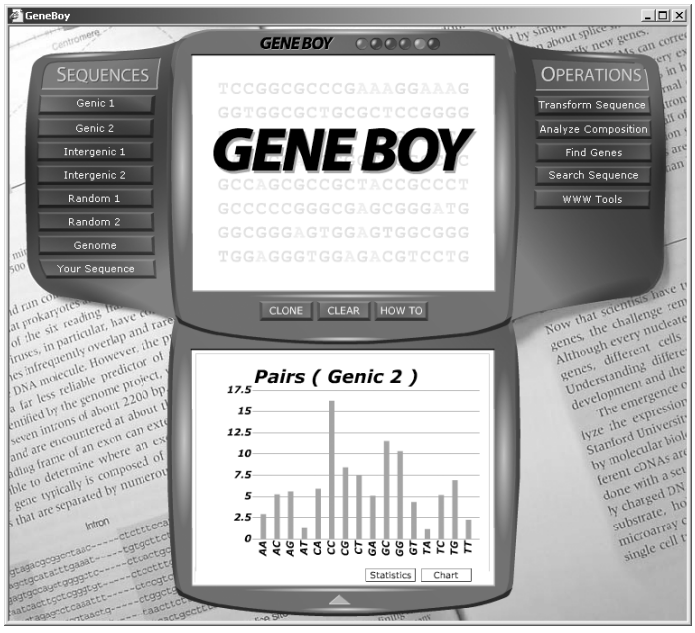
Flash Tools for Genome Bioinformatics

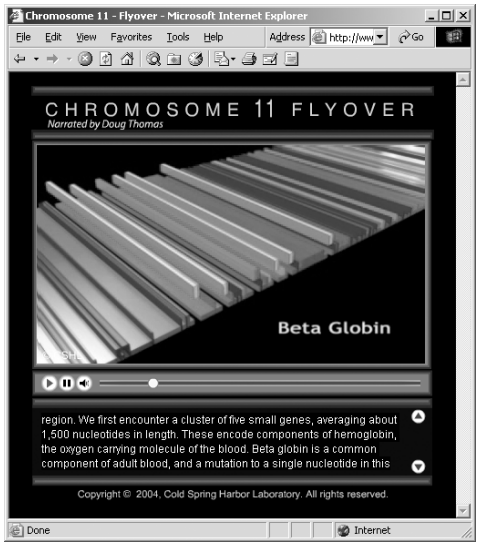
The DNALC began to rise to the challenge of bioinformatics in the mid 1990s, when we developed the first polymerase chain reaction (PCR)-based experiments to allow students to analyze their own DNA differences (polymorphisms) using simple agarose gel systems. This led to the development of the *Student Allele Database*, which allowed students to enter their class polymorphism data and compare it with research data from world populations. By the late 1990s, we had developed a simple system for amplifying mitochondrial (mt) DNA, and began to sequence DNA samples submitted from students around the country.

Our current *Bioservers* site (www.bioservers.org), released in 1999, introduced separate tools for analyzing allele data and sequence data in human populations. These intuitive interfaces allow students to enter their own data and draw data from a number of research sources, and then to manipulate the data sets in a common workspace. The *Allele Server* stores results of student experiments with the *Alu* insertion polymorphism PV92, and provides graphical tools for testing Hardy-Weinberg equilibrium and comparing allele and genotype frequencies. *Sequence Server* stores student mitochondrial control region sequences and provides tools for CLUSTALW analysis and BLAST searches. Registered users can save files of interest and return to their workspace to continue with projects they have initiated. Each of these tools conforms to several simple rules for constructing intuitive Internet tools: consistent and logical placement of tool bars, minimum use of submenus or "nested" screens, and minimal text.

In 2003, we began to experiment with "wrapping" sophisticated algorithms in an attractive multimedia "skin." In striving to create a simple and engaging interface, we finally gave in to our own analogy to a computer game. The result was *Gene Boy* (www.dnai.org/geneboy), a program with what we call "thingness"—the sense of being a real, onscreen object. One draws sequence data from buttons on the left side of the console and performs bioinformatic functions with buttons on the right: transform/format DNA sequence, analyze nucleotide composition, search for restriction sites or other short motifs, and find open reading frames. A "clone screen" feature allows the user to duplicate a result in a new screen for comparison with a second result, while "skin" color can be changed in the manner of desktop wallpaper.

Working with The Mill—a London post-production house that won an Academy Award for special effects in *Gladiator* and produced animated sequences for *Harry Potter I* and *II*—we also developed a





new way to visualize genome data. We color-coded all of the features of a 650,000-nucleotide region of human chromosome 11—gene exons and introns, as well as four classes of transposons ("jumping genes") and repeated DNA. We then created a three-dimensional (3-D) "perspective" view in which each feature of 100 nucleotides or longer is rendered as a colored key in a DNA "keyboard." The result is a narrated tour (www.dnalc.org/chr11/) that includes gene clusters encoding blood components (globins), transcription factors, and olfactory receptors. The 3-D tour makes it sensationally apparent that genes and intergenic regions are chock full of transposons. Because repetitive DNA is typically "masked" from genome presentations, this view is striking even for those who know that transposons account for about 50% of the human genome. Visualizing the extent of transposon intrusion on our genome makes it difficult not to be moved to ask the question: "Why?"

The development of *Gene Boy* and the *Chromosome 11 Tour* was made possible by the tight integration of design, programming, and biological knowledge in our *Biomedia* Group. We want to build upon these design prototypes to develop a set of full-functioned *Flash Tools* that provide new ways to visualize, manipulate, and compare genome data. The term *Flash Tools* embodies the fact that interfaces are built using the new-generation multimedia design software Flash MX, as well as their speed and ease of use. We envision a sequence analyzer with the ability to "decorate" a DNA sequence with features from successive analyses, as well as a 3-D genome browser that will literally add a new dimension to large-scale gene analysis. The interface will integrate with standard algorithms and reusable software components of the Generic Genome Browser at the Generic Model Organism Database (GMOD), which is co-managed by CSHL scientist Lincoln Stein.

HHMI Bioinformatics

In 2003, we concluded a four-year project, funded by the Howard Hughes Medical Institute (HHMI), to introduce students and teachers to principles of genome analysis. At the heart of the program is *VectorNet*, a portable computer laboratory consisting of 12 laptops linked to a laptop server via a wireless local area network (LAN). The server can distribute live Internet access through a single fast connection, or it can rely on its own mirror of the DNALC Internet site and local copies of bioinformatics tools and GenBank data sets. Fitting entirely in two plastic trunks, *VectorNet* converts any classroom or lecture space into a fully functional computer lab in minutes.

In the project's local program, *New York City Genes*, we worked intensively with 1965 students and 316 teachers from public high schools representing each of the five boroughs of New York City. In the national program, the *Vector Bioinformatics Workshop*, we provided training for 320 educators in 16 different locations:

Blood Center of Southeastern Wisconsin, Milwaukee, WI
Contra Costa County Office of Education, Pleasant Hill, CA
Coriell Institute for Medical Research, Camden, NJ
CIIT Center for Health Research, Research Triangle Park, NC
Fred Hutchinson Cancer Research Center, Seattle, WA
Foundation for Blood Research, Scarborough, ME
Kaiser Permanente Center for Health Research, Portland, OR
National Center for Biotechnology Information, Bethesda, MD
Oklahoma Medical Research Foundation, Okalahoma City, OK
Rockefeller University, New York, NY
Salk Institute for Biological Studies, La Jolla, CA
Southwest Foundation for Biomedical Research, San Antonio, TX
Stowers Institute for Medical Research, Kansas City, MO
Trudeau Institute, Saranac Lake, NY
Harbor-UCLA Research and Education Institute, Torrance, CA
Whitehead Institute for Biomedical Research, Cambridge, MA

During the teacher workshop, participants made extensive use of computer tools to learn principles of gene analysis—including DNA sequence annotation, gene structure and regulatory elements, gene families and whole-gene analysis, functional genomics and DNA arrays, and gene discovery using single nucleotide polymorphisms (SNPs) and other markers. Participants also amplified two DNA polymorphisms and used their own data as a starting point to investigate DNA data sets, population genetics, human origins, and disease mechanisms—illustrating the crossover between DNA experiments done *in vitro* (test tubes) and *in silico* (computers).

Our experience with this course has shown that bioinformatics analysis is more difficult to teach than are the seemingly complex lab procedures of molecular genetic analysis. Experience with the CSHL

postgraduate *Genome Access* course confirmed that novice postgraduates face the same difficulties in utilizing Internet resources as do the innovative teaching faculty who participated in the HHMI course. Thus, DNALC staff member Uwe Hilgert was invited to become a co-instructor of the postgraduate *Genome Access* course—to integrate many of the instructional methods we developed for the HHMI bioinformatics course.

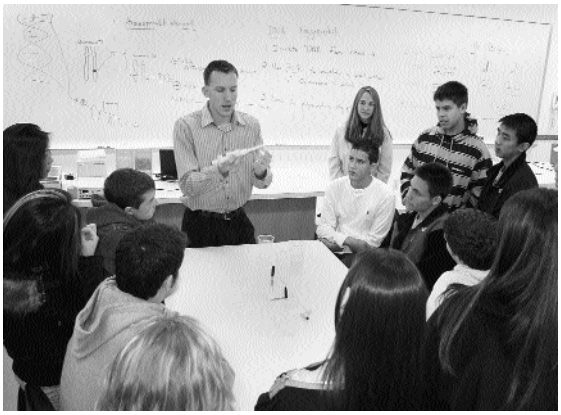
To gauge the impact of the *Vector Bioinformatics Workshop* on course participants, we conducted a follow-up survey of our 2001 alumni. Most participants reported that the workshop had enabled them to integrate into their own teaching instruction on the Human Genome Project (94.7%), bioinformatics (80%), DNA-typing/polymorphisms (78.2%), gene organization (76.4%), and human origins, evolution, and migration (80%). A significant number had integrated workshop content in hands-on computer exercises with their students (85.5%), including analysis of DNA sequence composition (73.3%), sequence searches (60%), sequence alignments (51.5%), construction of phylogenetic trees (46.7%), and gene prediction and/or protein structure examination (26.7%). A majority of respondents had also disseminated information about genomic biology/bioinformatics among colleagues, local teachers, and at workshops or meetings (73%).

Bioinformatics Lab Field Trips and Sequencing Service

The octagonal Bioinformatics Laboratory is the symbolic heart of our facility and is emblematic of the central role of computation in modern biology. A visit to the Bioinformatics Lab has been a key element of field trips for students doing PCR amplification of their own DNA polymorphisms. Middle school students have also used the laboratory for multimedia explorations of the forensic and DNA evidence used to identify the remains of the Romanov family (the last ruling family of Tsarist Russia), and to test whether or not claimant Anna Anderson was Anastasia Romanov. In 2003, we first offered a menu of pure bioinformatics field trips targeted at high school students:

- *Gene Sleuthing* Discover gene features that allow one to "mine" genes from the genomes of humans and other organisms.
- *Of Maize and Men: Jumping Genes Across Kingdoms* Uncover transposons in the genomes of corn and humans, discover how they "jump," and how they can contribute to disease.
- *Gleevec™: A Smart Bomb in the War on Cancer* Discover how the rational development of anti-cancer drugs critically depends on a thorough understanding of cell signaling pathways.
- *HIV: The Co-Evolution of Virus and Man* Discover how HIV evolved, how specific mutations lead to viral drug resistance, and why some people have natural resistance to infection.
- *Sickle Cell Anemia: A Disease of Diverse Populations* Discover the evolution of sickle cell disease, how the mutation affects red blood cells, and why the mutation persists in human populations.
- *Human Origins and the Story of Mitochondrial Eve* Reconstruct the human family tree to track down our most recent common maternal ancestor, and to discover where and when she lived.

During the year, our *Sequencing Service* processed more than 4000 student mitochondrial DNA samples submitted by 98 high schools and 56 universities and colleges. These sequences were then placed on our *Sequence Server*, where they can be viewed



Michael O'Brien leads a polymerase chain reaction (PCR) laboratory.

and analyzed by the students. The gift of a 377 DNA sequencer in 2000 by Applied Biosystems, plus continued donation of technical support and reagents, has allowed us to offer this service free-of-charge. However, demand is so great that this year we partnered with Dick McCombie's group at the Lita Annenberg Hazen Genome Sequencing Center to give us access to a fast, 96-capillary instrument. We are thankful for technical assistance from a number of genome center staff: Theresa Zutavern, Beth Miller, Andrew O'Shaughnessy, Lori Grady, and Jody Barditch.

New NSF Grants Increase Collaboration with CSHL Staff

Since its inception, the DNALC has looked to the research at CSHL for inspiration and a window on modern biology. On one hand, we attempt to predict which new areas of research may be important for students to learn about in the future. On the other hand, we try to identify "iconographic" lab experiments that illustrate new methods and subsume important biological principles. For example, our friendship with Doug Hanahan, in the mid 1980s, led us to adapt one of his simple methods to put DNA into bacteria. Today, this method is commonly used by high school and college students around the United States and Europe. The technique is so simple that we have been using it with 5th and 6th graders for several years.

Recently, we have been strengthening our ties to the main Laboratory campus, to the extent of submitting joint grants with CSHL researchers. The effort resulted in four awards from the National Science Foundation (NSF) on plant genetics and genomics, which represent a new degree of integration between high-level science and education outreach.

Plant molecular genetic and genomic research still lags behind medically oriented research on microbes and higher animals. As a result, there are relatively few lab experiences that expose college-level students to the growing insights into plants offered by genomic biology. Thus, our proposal to NSF to develop a laboratory- and Internet-based curriculum to bring college students up-to-the-minute with modern plant research struck a common chord with the six reviewers—all of whom rated it as "excellent." This is the first time in 15 years that any proposal we have submitted has received such a unanimous vote of confidence from NSF reviewers.

During the first year of this project, we developed a set of laboratories illustrating key concepts of gene analysis in plants, including the relationship between phenotype and molecular genotype, genetic modification of plants and detection of transgenes in foods, and linkage and bioinformatics methods for gene mapping. Key to the project are lab and bioinformatics exercises that will give students the unique opportunity to work with CSHL researcher David Jackson in determining the cellular analysis of *Arabidopsis* genes of unknown function. An Internet "super site," *Greenomes*, supports the laboratories with online protocols, custom analysis tools, shared databases, and collaborative bulletin boards. The new materials were introduced to Advisory Panel members at a workshop held June 16–20. Feedback from the Advisory Panel workshop is being used to refine curricula prior to initiating national dissemination workshops in 2004–2005. Faculty members from a number of key institutions attended the workshop:

Linnea Fletcher, Margaret Maher, Austin Community College
Robert Ballard, Barbara Speziale, Clemson University
Theresa Fulton, Sharon Mitchell, Cornell University
Erin Dolan, Fralin Biotechnology Center, Virginia Tech
Ed Himelblau, Long Island University at Southampton
Elizabeth Rosen, Noreen Warren, Madison Area Technical College
Katy Korsmeyer, Santa Clara Biotechnology Education Partnership
Leonore Reiser, The *Arabidopsis* Information Resource
Christine Pfund, Federico Luy, University of Wisconsin-Madison
David Jackson, Catherine Kidner, Lincoln Stein, CSHL

Later in the year, we received the news that the DNALC was co-awardee on three NSF research grants to sequence and annotate plant genomes. Under grants to Dick McCombie and Marja Timmermans, faculty/student pairs from universities serving predominantly underrepresented minorities will be awarded summer Fellowships at CSHL. During this intensive residence, Fellows will participate in plant research at the Woodbury Genome Sequencing Center and learn effective teaching strategies at the DNALC. Upon returning to their institutions, Fellows will work with DNALC staff to offer a train-

ing workshop on plant genomics for local biology faculty.

Under a grant to Lincoln Stein, DNALC staff will work with faculty Fellows to develop a *Student Genome Viewer*, an educational interface for annotating and comparing grain genomes. Then, a series of nationwide workshops will be held to train high school and college faculty to use *Genome Viewer* to detect potential errors and inaccuracies in gene predictions. Upon returning to their schools, faculty members will download a set of *ab initio* gene predictions from the DNALC server. They will then guide students in using *Genome Viewer* to evaluate predicted genes and to flag potential errors in exon/intron boundaries and other gene features. Student observations will be sent to database curators, whose suggested fixes and other comments will be shared with them.

DNA Interactive **Completed**

During the year, we completed *DNA Interactive* (*DNAi*, www.dnai.org), an Internet site to commemorate the 50th anniversary of the discovery of the structure of DNA. As executive producer of this $1.8 million project, the DNALC coordinated contributions from producers and designers in the United Kingdom and Australia—Windfall Films, The Red Green & Blue Company Ltd., The Mill, and The Walter and Eliza Hall Institute. The Internet site was part of a larger *DNA* project developed by an international collaboration of scientists, educators, and filmmakers. Other *DNA* products include a five-part TV series airing on PBS in 2004; *DNA: The Secret of Life* book coauthored by Nobel Laureate James D. Watson; a half-hour video for museums and science centers; and DVDs of the television series and *DNAi* teacher resources.

Funded by the Howard Hughes Medical Institute (HHMI), *DNAi* comprises six major topic areas: *Timeline, Code, Manipulation, Genome, Applications*, and *Chronicle*. The topics were serially released over a five-month period. By year's end *DNAi* had received 377,000 visits—making it our fastest-growing release to date. The topic areas (with the exception of *Timeline*) loosely follow the *DNA: The Secret of Life* television series. *DNAi* includes five hours of video footage drawn from extensive interviews with more than 70 scientists (including 11 Nobel Laureates). More than 150 animations illuminate key experiments in the history of DNA and bring to life the molecular processes that govern DNA replication and expression.

In producing *DNAi*, the *Biomedia* Group joined the upper echelon of multimedia design groups in the world. The site was produced entirely in Flash MX, which has the advantage of playing its own formatted video files, allowing for seamless integration of a video player into the Internet page itself. When coupled with video encoders, Flash formatting allows us to achieve 100-fold compression of video file size with surprisingly little loss of quality. Flash MX files require only a single plug-in for both animation and video playback, and 98% of Internet users already have a Flash-enabled browser. *DNAi*'s high level of multimedia design and technology integration was recognized when it was named "Site of the Day" by Macromedia, the manufacturer of Flash MX. The site also won *ScientificAmerican.com*'s 2003 Sci/Tech Web Award for biology resources, the Exploratorium's "Ten Cool Sites" Award for education excellence, and the Yahoo! Pick of the Day. We believe that the project now

sets the standard against which other Internet science education resources must be measured.

In November, we released *myDNAi* (www.dnai.org/members), a package of classroom resources and tools that allow teachers to create their own materials. Working closely with expert Teacher Fellows, we developed 15 lesson plans that include objectives, correlations to National Science Education Standards, student worksheets, preparation notes, and supplemental materials. The customized *DNAi* experience begins with the creation of a *myDNAi* homepage. This easily editable page includes a greeting, access to *DNAi* lesson plans, and Internet links. The customized homepage is stored on the DNALC server and is accessed by a unique URL.

myDNAi is also the access point for *Lesson Builder*, our unique editor that allows teachers to build custom lessons from more than 1000 multimedia objects (video, animations, photos, transcripts, text) used to construct the *DNAi* Internet site. A keyword search looks for matches among more than 20 metadata fields that describe each object. Then, using a simple "drag-and-drop" editor, the teacher selects and organizes the multimedia objects into a lesson. Each teacher lesson is then saved on the DNALC server and accessed by students using a unique URL associated with the teacher's profile. A lesson can be modified and saved in different versions for use in different classes. In the final two months of 2003, more than 2400 people had registered as *myDNAi* members, and nearly 400 custom lessons had been developed.

Eugenics Image Archive **Nearly Completed**

The *Image Archive on the American Eugenics Movement* Internet site was conceived in 1995, soon after the DNALC launched its first primitive home page. We saw the Internet as the perfect medium to introduce students, teachers, and the public to this hidden period in scientific history. After several tries, we were ultimately awarded a two-year grant from the Ethical, Legal, and Social Issues (ELSI) Program of the National Human Genome Research Institute in early 1998; then, a continuation grant extended support to March 2004.

The *Archive* now contains more than 2200 images of photographs, lantern slides, correspondence, journals, texts, manuscripts, charts, and data. About 900 text-rich images have been transcribed as text-only files, which allow the content to be searched by our database engine. The images represent collections from 11 institutions: American Philosophical Society Library, Philadelphia; Cold Spring Harbor Laboratory Archives, New York; Ellis Island/Statue of Liberty National Monument, New York; International Center of Photography, New York; Max Planck Society Historical Archives, Berlin; Rockefeller University Archive Center, New York; State University of New York at Albany; Truman State University Archives, Missouri; University College, London; University of Tennessee at Knoxville; and University of Virginia.

The content of the *Archive* was significantly bolstered in 2003 by the addition of the Flash MX module *Chronicle* (www.dnai.org/e/index.html), developed as part of the *DNAi* project. Using mental illness as a common thread of eugenic concern during the first half of the 20th century, *Chronicle* fuses a linear narrative with browsable "exhibits" drawn from the *Archive*. The presentation highlights the experiences of five individuals—four who became objects of the eugenic movement's zeal to cleanse society of "bad" genes, and one modern-day heroine who provides a personal account of mental illness and the lesson it holds for living in the "gene age." Paul Lombardo, of the University of Virginia, provides a narrated tour of the people and places involved in the pivotal trial of Carrie Buck, which legalized eugenic sterilization in the United States. In another moving sequence, Benno Müller-Hill takes James Watson on a tour of a gas chamber in Bernberg psychiatric hospital, where the Nazis enforced a "final solution" to mental illness.

Since its public launch in 2000, the *Eugenics Archive* has received 580,000 visitors. Visitation increased 32% in 2003, with nearly a quarter of a million people spending an average of 13 minutes at the site (equivalent to over six person-years of viewing!). The *Archive* has been recognized as a *USA Today* "Hot Site" and one of the Exploratorium's "Ten Cool Sites"; it recently received a high rating in

an in-depth review of Internet sites on the Progressive Era by the Public History Resource Center (publichistory.org/reviews/view_issue.asp?IssueNumber=9). We regularly receive requests for use of *Archive* images from traditional and online publications and broadcast media. Most notably, *Archive* images have been seen in "Race and Membership in American History: The Eugenics Movement" from *Facing History and Ourselves*, "How to Build a Human" broadcast on BBC television, "American Gothic" by Christopher Reardon for *Teaching Tolerance* Magazine, "Race Cleansing in America" by Peter Quinn for *American Heritage* Magazine, "Never Again" by Ward Harkavy for *The Village Voice*, "Breeding Better Citizens" by Valerie Parker for ABC News, and "Race: The Power of an Illusion" by California Newsreel for PBS.

The last in a series of three meetings funded under our National Institutes of Health (NIH) grant, *American Eugenics and the New Biology: Perspectives and Parallels*, was held at Banbury Center October 14–16. *Archive* advisors Garland Allen (Washington University of St. Louis), Elof Carlson (State University of New York at Stony Brook), Paul Lombardo (University of Virginia), and Steve Selden (University of Maryland) were joined by Nicholas Gillham (Duke University), Conrad Gilliam (Columbia University), Nancy Segal (California State University, Fullerton), and Kay R. Jamison (Johns Hopkins School of Medicine) in speaking on a range of topics designed to provoke thinking about the "old" and potentially "new" eugenics. Talks moved from an in-depth look at the founder of British eugenics, Francis Galton, to eugenic sterilization in the United States, to twin studies and the modern search for genes behind mental illness. The series drew 80 opinion leaders from diverse fields, including family genetics, education, ethics, journalism, government, industry, and philanthropy.

Participants in the *Eugenics and the New Biology: Perspectives and Parallels* Banbury meeting have an informal discussion between sessions.

Inside Cancer in Full Production

Upon completion of the *DNAi* project, the focus of the *Biomedia* Group turned to *Inside Cancer*—a multimedia Internet site for teachers, students, and family members who want authoritative information on how knowledge of the cancer cell is changing cancer diagnosis and treatment. Funded by an NIH Science Education Partnerships Award (SEPA), *Inside Cancer* is benefiting from the Flash MX technology we mastered in building *DNAi*. With Flash MX, we can now build presentations that focus on telling the story with the most appropriate media, or combination of media types.

Inside Cancer will feature interviews with cancer researchers and other experts to help people understand the complex science and issues of cancer. These interviews will appear both as standalone features on the site and as integrated presentations with the interviewees narrating animations that show the inner workings of cancer cells. More than 15 cancer researchers, clinicians, and epidemiologists have been interviewed to date—including pioneers Judah Folkman, Doug Hanahan, Edward Harlow, Arnold Levine, Harold Varmus, and Robert Weinberg.

The content is broken into five modules. *Hallmarks of Cancer* emphasizes cancer as a genetic dis-

One of the first completed components of the *Inside Cancer* Internet site is the *Pathways to Cancer* 3-D animation. In this clip, the signal is conducted through the cell membrane, into the cytoplasm. The PDGF receptor is the large molecule just to the right of center.

ease and highlights the common features of a cancer cell. *Causes & Prevention* uses epidemiological data to highlight behaviors and environmental factors that increase cancer risk. *Diagnosis & Treatment* shows how new molecular techniques are being used to diagnose and tailor cancer treatment according to specific genetic changes in the patient's tumor. *Cancer in the Laboratory* introduces major cancer researchers and the importance of their discoveries in understanding cancer at the molecular level. *Pathways to Cancer* is a 3-D tour of a cell that focuses on the signaling pathway through which growth commands are transmitted from the cell surface to the nucleus. All of the modules will be linked through a "molecule menu" that acts as an illustrated glossary for quick reference information on specific genes and proteins involved in oncogenesis.

A major development effort has focused on finishing high-resolution 3-D animations of a cell's signaling pathway for the *Pathways to Cancer* module. These animations, produced with Interactive Knowledge, Inc., enable users to follow a pathway initiated by platelet-derived growth factor (PDGF) to illustrate the key points at which cellular growth control can be lost during oncogenesis. The importance of protein products of proto-oncogenes c-*sis*, *ras*, c-*fos*, c-*jun*, and the role of phosphorylation in the regulation of protein function are illustrated. Since the PDGF receptor is a target for the new Novartis drug Gleevec™, the pharmacological action of cell signaling inhibitors will also be stressed. The signaling animations will be completed early in 2004, when voiceover artist Doug Thomas records a narration track. Doug is the son of Peter Thomas, who did voiceover for the award-winning video, *The Biological Revolution*, produced as part of the Laboratory's centennial celebration. A 12-minute version of the animation, entitled *Cell Signals*, will be produced in wide-screen format for presentation in the DNALC's auditorium.

DNA Science **2nd Edition**

In mid January, we received the first copies of the second edition of our popular lab text, *DNA Science*. The 2nd edition preserves the successful formula of the 1st edition: one part well-tested laboratories and one part insightful, explanatory text. First published in mimeographed form in 1988 and formally published in 1990, this book was largely responsible for bringing DNA experiments within reach of advanced high school and beginning college students.

The core laboratory sequence, developed by myself and Greg Freyer in the laboratory of CSHL Nobel Laureate Richard Roberts, introduces the basic techniques of DNA restriction, transformation, isolation, and analysis—and then applies these techniques to the construction and analysis of a simple recombinant DNA molecule. We resisted the temptation to tinker very much with the laboratories,

since they are the best-tested and most widely used teaching labs available on the basic techniques of gene manipulation. Two new labs were added that focus on gene products: a colorimetric assay for the activity of β-lactamase, the enzyme produced by the ampicillin resistance gene, and expression and purification of green fluorescent protein.

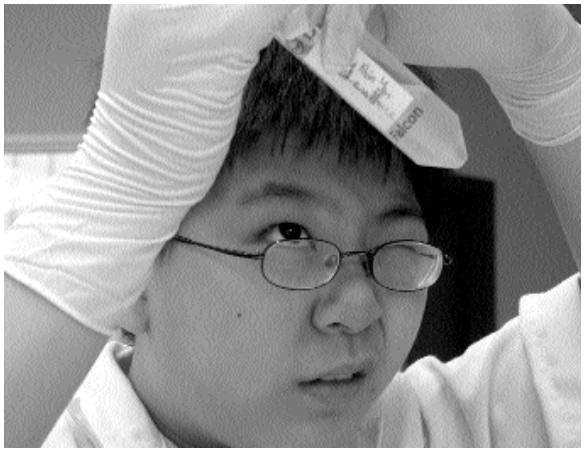
The text portion has been entirely reorganized and updated, increasing from 200 to 300 pages. As before, the narrative takes students behind the scenes of modern research to show them the evolution of concepts and methods. The first three chapters cover essential principles of genetics, and DNA structure and function. The next three chapters introduce small- and large-scale methods for analyzing DNA, culminating in the race to sequence the human genome and new methods for working with hundreds of genes simultaneously. The final two chapters focus on the applications of molecular techniques to understand cancer, human variation, and our emergence as a species. The human genetics chapter also contains the first substantial treatment of the American eugenics movement available in a general biology text.

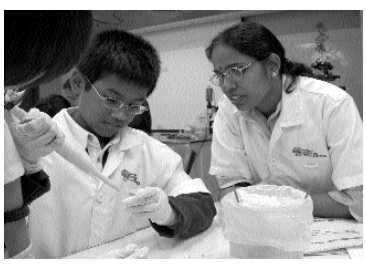
Although much has changed in biology since the first edition, the ideas and techniques in this book are still the minimum requirements for any degree in DNA manipulation. We hope that *DNA Science* continues to provide a simple roadmap for beginning an exploration of the molecule of life—one that will take on added importance as more and more biology teachers around the world realize the value of giving students freedom to get their hands dirty with DNA.

DNALCs to the North, South, East, and West

Over the years, the DNALC has been the direct model for a number of teaching laboratories established at museums and higher education institutions in the United States and abroad, including Biogen Community Laboratory (Boston, Massachusetts), Tech Museum of Innovation (San Jose, California), Life Science Centre (Newcastle, England), Visible Laboratory (Berlin, Germany), DNA School (Montpelier, France), and Life Learning Center (Bologna, Italy). In 2001, the DNALC initiated a formal program to assist institutions and governments that wish to quickly and efficiently implement a "hands-on" science center devoted to modern biology education. Under the licensing scheme, institutions have transparent access to teaching methods, Internet technology, and intellectual property ("know-how") developed at a cost of more than $25 million.

In 2003, Clemson University and Roberson Museum and Science Center joined the ranks of current licensees: North Shore–Long Island Jewish (LIJ) Health Care System, Singapore Ministry of





Students in the DNA Learning Lab at the Singapore Science Centre participate in hands-on activities.

Education, and Science Epicenter and DNA Learning Center. Clemson initiated the South Carolina DNA Learning Center with an initial grant of $500,000, with the intent to focus on agricultural genetics. Working with a consortium of local business people and educators at the University of Binghamton, Roberson had raised nearly $1 million to support development of its Life Science Learning Center.

The DNALC *West* facility, adjacent to North Shore–LIJ's clinical testing laboratory in Lake Success, served 2050 students during its first full year of operation. Located 18 miles west of Cold Spring Harbor, this facility was designed to serve students in western Nassau County and New York City. Within a year of signing a licensing agreement, two facilities based on the DNALC model came online in the Republic of Singapore—one to serve teachers and the other to serve students. The DNA Centre at the National Institute of Education (NIE)—with two teaching labs, a bioinformatics lab, and small exhibit space—provided workshops for 625 teachers in 2003. The DNA Learning Lab at the Singapore Science Centre—with dual "Watson" and "Crick" teaching labs surrounded by a "DNA Trail" exhibit—conducted experiments with 6356 visitors and held orientations for 1200 educators. Science Epicenter and DNA Learning Center—across Long Island Sound in Groton, Connecticut—equipped its first teaching lab with the help of Pfizer, Inc. and began offering field trips in the fall.

Real and Virtual Programs Continue to Grow

Thanks to the availability of new lab space at the *West* facility, the number of students participating in lab field trips rose 8% in 2003, to 15,604. The 798 students who participated in summer "DNA camps" represented a similar increase over the previous year. *Gratis* labs and summer camps were provided to nearly 800 students from public schools in Nassau County, Suffolk County, Brooklyn, Manhattan, and the Bronx. We had another busy summer, instructing more than 600 student participants in 26 workshops sited at the DNALC and at Central Islip High School (Suffolk County), Bard High School Early College (Manhattan), and Science Epicenter and DNA Learning Center (Groton, Connecticut). Nearly 250 teachers participated in training workshops (two or more days long) conducted by DNALC staff here, in Singapore, and at locations around the United States. This brings the total number of teachers who we have trained since 1985 to 3500. Nearly 8000 visitors viewed Cablevision's *Long Island Discovery* and *The Genes We Share* Exhibit. All tolled, DNALC visitation reached a new peak of 33,351.

Although DNALC visitation is limited by space, time, and staff, our capacity for "virtual" visitors via the Internet is essentially unlimited. Thus, the family of Internet sites reached through the DNALC's portal, *Gene Almanac*, provide us with a large and growing clientele of students, teachers, medical consumers, and concerned lay people. Traffic at DNALC Internet sites increased 23%, with 4.85 million visitors each spending an average of 11 minutes.

Genetics as a Model for Whole Learning (*GMWL*), our program of in-school instruction and lab field trips for 4–8th graders, reached 16,000 students in 60 school districts and private schools during the year. Middle school students continued to enjoy a variety of laboratory experiences—from making cell models of gelatin and dry foodstuffs to producing glowing bacteria using GFP (green fluorescent protein) transformation. The instructional staff used the *DNAi Lesson Builder* to create a new computer lab in which students compare fossils of ancient hominids and explore the diversity of mitochondrial DNA. This complements a student's visit to the adjacent exhibit on *Common Origins*.

High school students enjoyed the debut of two new labs. In *Doggy DNA*, students isolate DNA from cheek cells of their favorite pooch (or prepared cells provided by staff) and then use PCR to amplify a short region of the mitochondrial chromosome. Several days after the visit, DNALC staff post the sequences on our *Sequence Server*, where teachers and students can retrieve their canine DNA and use it to study the evolution of domesticated dogs. In the *Genetically Modified Organisms* lab, students use PCR and gel electrophoresis to detect transgenes in genetically modified soybeans and common foodstuffs.

The long-running *Curriculum Study* Program attracted 37 member districts and schools, from which come a majority of student lab participants. *Curriculum Study* members have preferred access to the

DNALC and select from a "menu" of benefits and services—including free and reduced-rate lab field trips, first option on summer workshops, seminars by world class scientists, and teacher in-service training. *Great Moments in DNA Science*, the *Curriculum Study* honors seminar series, hosted 442 students over three evenings of talks presented by CSHL scientists Thomas Volpe, Richard McCombie, and Yuri Lazebnik.

We continued to welcome families from the local area to the DNALC for the *Saturday DNA!* Program. In 2003, more than 300 children, teens, and adults participated in 90-minute laboratory- or computer-based sessions offered by DNALC staff. During lab sessions, participants compared DNA samples at mock crime scenes, mapped DNA mutations, and experimented with jumping genes. In computer-based sessions, participants learned how to create scientific animations, explored molecular biology resources on the Web, and searched for meaning in DNA sequences. In addition, more than 900 members of the public attended "DNA at 50," a series of nine special lectures given by CSHL Chancellor James Watson to commemorate the 50th anniversary of his own discovery of the structure of DNA.

Pfizer Leadership Institute

The highlight of the summer was the Pfizer *Leadership Institute in Human and Plant Genomics*. Nicknamed "DNA Boot Camp," the three-week institute drew together 19 of the very best biology teachers from around the United States, as well as five teachers from the Republic of Singapore. Staying on the CSHL campus is a dream come true for these teachers. Here, they literally walk in the shadows of heroes—living, eating, and breathing science. For most, it is a defining moment in their careers. The participating teachers have already implemented major genetics/biotechnology teaching programs at their schools prior to attending the Pfizer *Institute*. The institute honors their past creativity and prepares them to take their innovative classroom teaching and peer training to even higher levels.

The 2003 institute focused on the study of human and plant genomes, and included a section on site-directed mutagenesis and genetically altered food crops. All topics were addressed in a three-pronged approach of lectures/seminars, wet-labs, and computer work. Five CSHL research scientists gave seminars on topics that extended participants' understanding of the course materials. Participants also visited CSHL's Uplands Farm field station for plant genetics and the newly completed Genome Sequencing Center. Finally, teachers were provided with independent time to begin developing curriculum materials for use in their own classrooms, as well as for the training of colleagues in their local regions.

A survey of past *Leadership* participants revealed that they, indeed, are living up to their role as educational leaders. Participants reported that they had provided 227 hours of in-service training for 400 precollege faculty—an average of 11 hours and 19 faculty trainees per participant. These events provided faculty hands-on experience in many lab and computer methods, including gel electrophoresis (211 teachers), bioinformatics (111 teachers), PCR (98 teachers), protein purification (50 teachers), and bacterial transformation (34 teachers). *Leadership* faculty also reported receiving more than $80,000 in funding to purchase lab equipment and supplies, to provide in-service training, and to attend professional meetings.

2003 *Leadership Institute* participants and DNALC staff.

Staff and Interns

Mary Lamont and Carolyn Reid joined the administrative staff in 2003.

In 2003, we welcomed two new members to our Administrative staff: Carolyn Reid and Mary Lamont. Carolyn joined us in May as an Administrative Assistant at the DNALC, helping with schools administration and our *Saturday DNA!* Program. A Long Island native, Carolyn has experience in the travel, cable television, and publishing industries. Mary began in September as an Administrative Assistant for the growing operation at the DNALC *West*. Prior to joining CSHL, Mary worked in entertainment management, magazine publishing, and insurance-related companies.

In 2003, we bid farewell to three staff members. After making valuable contributions to the *DNA Interactive* project, science writer Beverly Tomov left in September to look after her new baby, Sophia. Designer Karwai Pun also left the *Biomedia* Group, but continues her relationship with CSHL as a member of the Graphic Arts Department. After returning to the DNALC following maternity leave, Tricia Maskiell took a position as a 6th grade science specialist at Oldfield Middle School, in the neighboring Harborfields School District.

High school interns continue to provide key support for our teaching labs, as well as conducting independent research projects under the direction of Scott Bronson and Jennie Aizenman. Intern Michelle Louie (Kings Park High School) was selected as an Intel semifinalist for her work on tagging *Arabidopsis* genes of unknown function with green fluorescent protein (GFP). Benjamin Blond (Syosset High School) is attempting to use RNA interference (RNAi) to "silence" a *C. elegans* gene believed to be involved in the aging process. Two DNALC *West* interns moved on to pursue higher-level research: Robert Weintraub (Walt Whitman High School) is working on DNA polymorphisms in *Arabidopsis* with Zachary Lippman at CSHL. Alinea Noronha (Herricks High School) was accepted into the Young Investigators Internship at the Research Institute of NS–LIJ Medical System.

Regina Hui (Northport High School), Ariel Gitlin (Cold Spring Harbor High School), and Watson School student Elizabeth Thomas continued to assist the *Biomedia* Group with Internet site development.

Joining the intern program in 2003 were Carisa Bautista (Cold Spring Harbor High School), Joe Hakoopian (Walt Whitman High School), Zach Goldberg (Half Hollow Hills East High School), Amy Richards (Kings Park High School), George Roche (Cold Spring Harbor High School) and Greg Rosen (MacArthur High School). Jason Wittenstein (Herricks High School) and Zeba Izhar (Queensborough Community College) joined the intern crew at DNALC *West*. Several interns returned from college to assist with summer workshops: Yan Liang Huang (Notre Dame University), Janice Lee (Boston University), and Alex Witkowski (SUNY Albany).

In August, we bid farewell to a number of interns as they began their freshman year at college: Lara Abramowitz (Half Hollow Hills West High School) at the University of Rochester; Kunal Kadakia (Syosset High School) at Northwestern University; Shirish Kondabolu (Half Hollow Hills West High School) at the University of Rochester; Jared Winoker (Syosset High School) at Cornell University, and Jonathan Mogen (Half Hollow Hills West High School) at Brown University. Pushpa Abraham (Kings Park High School) traveled to India to attend medical school, and Rebecca Yee entered a Masters-level program in genetic counseling at Virginia Commonwealth University.

Dave Micklos

2002 Workshops, Meetings, and Collaborations

January 2	Site visit by Barry Aprison, Museum of Science and Industry, Chicago, Illinois
January 13	Site visit by Barbara Suhr, New York Public Library, New York, New York
January 17	Site visit by Phil Lamesch, Harvard Medical School, Boston, Massachusetts
January 21	Site visit by Anna Nasmyth and Gustav Ammerer, Mendel Museum of Genetics, Brno, Czech Republic
January 24–25	European Molecular Biology Laboratory Education Advisory Board Meeting, Heidelberg, Germany
January 24	Site visit by Mark Bloom, Biological Sciences Curriculum Study, Colorado Springs, Colorado
January 25	*DNA at 50: Finding the Double Helix*, talks by James D. Watson, DNALC
January 27	Site visit by the Bruce Museum, Greenwich, Connecticut
January 29	National Institute of Social Sciences Issues Discussion Group, Colony Club, New York, New York
January 29–31	National Coalition for Health Professional Education in Genetics Annual Meeting, Bethesda, Maryland
January 31	Site visit to Roberson Museum and Science Center, Binghamton, New York
February 4	Site visit to Molloy College, Rockville Centre, New York
February 8	*DNA at 50: Finding the Double Helix*, talks by James D. Watson, DNALC
February 14	Site visit by Mark Hertle, Precollege Science Education Program, Howard Hughes Medical Institute, Chevy Chase, Maryland
February 15	*DNA at 50: Finding the Double Helix*, talks by James D. Watson, DNALC
February 20–21	National Institutes of Health Science Education Partnerships Award Directors Meeting, La Jolla, California
February 25–27	National Institutes of Health Science Education Partnerships Award Review Panel, Bethesda, Maryland
February 27–March 1	*Meeting the Challenges in Emerging Areas: Education Across the Life, Mathematical, and Computer Sciences* Meeting, Bethesda, Maryland
February 28	Site visit by Jon King, National Human Genome Research Institute, Bethesda, Maryland
March 5	Site visit by Hutton House faculty and members, C.W. Post campus, Long Island University, Brookville, New York
March 8	*Saturday DNA!* Seminar, DNALC
March 17–24	Teacher-training workshops, National Institute of Education and Singapore Science Centre, Singapore
March 19–22	*Museums and the Web* Meeting, Charlotte, North Carolina
March 22	*Saturday DNA!* Seminar, DNALC
March 25	*Great Moments in DNA Science* Honors Students Seminar, CSHL
March 27–30	Exhibit at National Science Teachers Association Annual Meeting, Philadelphia, Pennsylvania
March 28	Site visit by News 12 Long Island, to film high school field trip
March 31	Site visit by Kathy Belton, Audrey Cohan, Valerie Collins, Jodi Kilgannon, Ed Thompson, and Ron Zanni, Molloy College, Rockville Centre, New York
April 1	*Great Moments in DNA Science* Honors Students Seminar, CSHL
April 2	Eugenics Seminar at Lycoming College Genome Symposium, Williamsport, Pennsylvania
April 3	Site visit by Jennifer Cordi and Judy Cohen, Bard High School Early College, Manhattan, New York Presentation at Sayville High School Career Café, West Sayville, New York
April 5	*Saturday DNA!* Seminar, DNALC
April 8	*Great Moments in DNA Science* Honors Students Seminar, CSHL
April 11	Site visit by Fran Balkwill, Barts & The London, Queen Mary's School of Medicine and Dentistry, London, United Kingdom
April 15	Site visit by Callie Brunelli, Aubrey Clark, Denise Gay-Alden, Kristen Gordon, Jim Griffin, Jim Lee, and Nancy Scales, Roberson Museum and Science Center, and Tom O'Brien and Theresa Partell, SUNY Bingahamton
April 16	Science Epicenter and DNA Learning Center Board Meeting, New London, Connecticut
April 19	*Saturday DNA!* Seminar, DNALC
April 30	National Institute of Social Sciences Issues Discussion Group, Harvard Club, New York, New York
May 3	*Saturday DNA!* Seminar, DNALC
May 6	Presentation to Academy of Professional Law Enforcement, CSHL
May 13	Site visit by members of the Huntington Rotary Club, Huntington, New York
May 17	*Saturday DNA!* Seminar, DNALC
May 19	Site visit by Robert Ballard, Richard Hilderman, and Calvin Schoulties, Clemson University, Clemson, South Carolina

May 22	Sayville School Business Advisory Board Meeting, Sayville High School, West Sayville, New York
May 27	Site visit by Estelle Perera, The Tech Museum of Innovation, San Jose, California
	National Institute of Social Sciences Annual Board Meeting, Colony Club, New York, New York
May 30	Site visit by participants in the CSHL Symposium *The Genome of Homo Sapiens*
May 31	Saturday DNA! Seminar, DNALC
June 3	Site visit by Linnea Fletcher, Austin Community College, and Sue Gravett, Brandon Janes, and Charles Lutz, Austin Chamber of Commerce, Texas
June 9	*DNA: The Secret of Life* book signing, James D. Watson, DNALC
June 10	Site visit by Jean Caron and Carol Milne, Science Epicenter and DNA Learning Center, New London, Connecticut
June 13	Site visit by Jim Lee, Ann Van Atta, Miranda Green-Barteet, and Nancy Scales, Roberson Museum and Science Center, Binghamton, New York
June 14	*Saturday DNA!* Seminar, DNALC
June 16–20	National Science Foundation Advisory Panel Workshop, DNALC
	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, CIIT Center for Health Research, Research Triangle Park, North Carolina
June 23–27	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, Blood Center of Southeastern Wisconsin, Milwaukee
June 26	Site visit by Horst Saalbach and Berndt Kynast, Faustus Forschungs Compagnie, Leipzig
June 26–July 2	*Fun With DNA* Workshop, DNALC
	World of Enzymes Workshop, DNALC
	DNA Science Workshop, DNALC
July 1–3	DNA polymorphisms workshop, International Genetics Congress, Melbourne, Australia
July 6–11	International Congress of Genetics, Melbourne, Australia
July 7–11	*Fun With DNA* Workshop, DNALC
	World of Enzymes Workshop, DNALC
	Green Genes Workshop, DNA Learning Center *West*
	DNA Science Minority Workshop, Central Islip High School
July 7–25	Pfizer *Leadership Institute in Human and Molecular Genomics,* DNALC
	Training for Singapore collaborators, Daniel Chua Wei Sheong, Muhammad Shahrin, Nai Sok Khoon Karine, Elaine Tan Pei Lee, and Florence Francis
July 8	Seminar at Human Genetics and Global Healthcare Symposium, Melbourne, Australia
July 14–18	*Fun With DNA* Workshop, DNA Learning Center *West*
	Green Genes Workshop, DNALC
	DNA Science Workshop, DNALC
	Training for Science Epicenter and DNA Learning Center collaborators, Pat Quinn and Nancy Scales
July 15	Site visit by Alan Fleischman and Leslie Goldman, New York Academy of Medicine, New York, and Lawrence Sherr, North Shore–Long Island Jewish Health System, Manhasset, New York
July 18	Site visit by the Alliance for Graduate Education and Professionals, State University of New York, Stony Brook
July 21	Presentation at National Institutes of Health workshop, *Genes, Schemes, and Molecular Machines*, Schenectady, New York
July 21–25	*Fun With DNA* Workshop, DNALC
	World of Enzymes Workshop, DNA Learning Center *West*
	DNA Science Workshop, DNALC
`	*DNA Science* Minority Workshop, Bard High School Early College
	DNA Science Workshop, Science Epicenter and DNA Learning Center, New London, Connecticut
July 28–August 1	*World of Enzymes* Workshop, DNALC
	Green Genes Workshop, DNALC
	Genetic Horizons Workshop, DNALC
	DNA Science Workshop, DNA Learning Center *West*
	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, Coriell Institute for Medical Research, Camden, New Jersey
August 4–8	*Fun With DNA* Workshop, DNALC
	Fun With DNA Workshop, DNA Learning Center *West*
	World of Enzymes Workshop, DNALC
	Genomic Biology and PCR Workshop, DNALC

August 4–8	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, Harbor-UCLA Research and Education Institute, Torrance, California
August 4–22	Training for Singapore collaborators, Chow Wai Hoong, Ramiah Kamala, and Yam Wei Ling Agnes
August 11–15	*Fun With DNA* Workshop, DNALC
	Green Genes Workshop, DNALC
	DNA Science Workshop, DNALC
	Genomic Biology and PCR Workshop, DNA Learning Center *West*
	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, Kaiser Permanente Center for Health Research, Portland, Oregon
	Training for Science Epicenter and DNA Learning Center collaborator, Nancy Scales
August 12	Site visit by alumni group from Brandeis University, Waltham, Massachusetts
August 13	Site visit by Karl Kuchler, University of Vienna, Austria
August 18–22	*Fun With DNA* Workshop, DNALC
	World of Enzymes Workshop, DNALC
	DNA Science Workshop, DNALC
	DNA Science Workshop, DNA Learning Center *West*
	Howard Hughes Medical Institute, *Vector Bioinformatics* Workshop, Rockefeller University, New York, New York
August 25–29	*Fun With DNA* Workshop, DNALC
	Genetic Horizons Workshop, DNALC
	Genomic Biology and PCR Workshop, DNALC
September 3	Site visit by Henry Yang, Beijing Genomics Institute, China
September 9	Dedication of Joan and Arthur M. Spiro Auditorium, *Nature, Nurture & Mental Illness*, talks by Matt Ridley, Kay Redfield Jamison, and Andrew Solomon, DNALC
September 10	Presentation at Melbourne Museum, Australia
September 20	*Saturday DNA!* Seminar, DNALC
September 25	Eugenics seminar at the New York Public Library, New York
September 26	Site visit and curriculum development meeting, Southampton College–Long Island University, New York
September 30	*Inside Cancer* interview, Arnold Levine, Princeton University, Princeton, New Jersey
October 1–3	Site visits to China Academy of Science and Technology and Natural History Museum, Beijing, China
October 2	Sayville School Business Advisory Board Meeting, Sayville High School, West Sayville, New York
October 4	*Saturday DNA!* Seminar, DNALC
October 6	Dedication of James D. Watson Institute of Genome Sciences, Zhejiang University, Hangzhou, China
October 8–11	Exhibit at National Association of Biology Teachers Annual Meeting, Portland, Oregon
October 11	Site visit and tour by students and faculty from the Center for Talented Youth, Johns Hopkins University, Baltimore, Maryland
October 13–16	National Institutes of Health ELSI conference, *American Eugenics and the New Biology: Perspectives and Parallels*, Banbury Center, CSHL
October 15	Site visit to Roberson Museum and Science Center, Binghamton, New York
October 16–17	National Human Genome Research Institute ELSI Project, *Eugenics Image Archive*, Editorial Working Group Meeting
	Bio 21: Teaching Biology With Bioinformatics Meeting, University of North Carolina at Chapel Hill
October 18	*Saturday DNA!* Seminar, DNALC
October 20–23	Site visit by Yan Yaw Kai, National Institute of Education, Singapore
October 22	Site visit by members of the National Institute of Social Sciences, New York, New York
October 24	*Inside Cancer* interview, Harold Varmus, Memorial Sloan-Kettering Cancer Center, New York
	Site visit by Dixie Scovel and Tony Wills, *Newsday*, Melville, New York
October 28–31	Site visit to International Centre for Life, Newcastle, National Centre for Biotechnology Education, Reading, and The Mill, London, United Kingdom
October 29	Teacher-training workshop, Erasmus Hall High School and STAR High School, Brooklyn, New York
November 1	*Saturday DNA!* Seminar, DNALC
November 3	Site visit by Arthur Spiro, CSHL Trustee and DNALC Committee Chairman, and James and Marcia Barker, Calvin Schultheis, Mendel Bouknight, and Robert Ballard, Clemson University, Clemson, South Carolina
	Inside Cancer interview, Larry Norton, Memorial Sloan-Kettering Cancer Center, New York
November 4	*Inside Cancer* interview, Bob Weinberg, Whitehead Institute, Cambridge, Massachusetts

	Inside Cancer interview, Stanley Korsmeyer, Dana-Farber Cancer Institute, Boston, Massachusetts
	Teacher-training workshop, Erasmus Hall High School and STAR High School, Brooklyn, New York
November 5	Site visit by Don Colbert, State University of New York at Binghamton
	Inside Cancer interview, Ed Harlow, Harvard Medical School, Boston, Massachusetts
	Teacher-training workshop, Biogen, Cambridge, Massachusetts
November 6	*Inside Cancer* interview, Marianne Berwick, Memorial Sloan-Kettering Cancer Center, New York
November 7	Videoconference with James D. Watson and National Institute of Education, Singapore
November 10–22	Teacher-training workshops, National Institute of Education, Singapore
November 11	Site visit by Jiaan Cheng, Zhejiang University, Hangzhou, China, and Sun Zhongsheng, Cornell University, Ithaca, New York
November 15	*Saturday DNA!* Seminar, DNALC
November 19	American Association of University Women Excellence in Science Awards Reception and Meeting, DNALC
	Teacher-training workshop, Erasmus Hall High School and STAR High School, Brooklyn, New York
November 20	Site visit by Curt Engelhorn, Monte Carlo, Monaco
	Site visit by Kent Anderson and Bette Phimister, *New England Journal of Medicine*, Waltham, Massachusetts
December 1–12	Training for Singapore collaborators, Wong Poh San, Ng Huey Bian, Evan Yap Boon Heng, Teo Lay Yen, Tan Wei Ling, Wong Mei Leng, and Tan Woei Yng
December 2	Site visit by Clare Lin, national winner of the GenETHICS Competition, Melbourne, Australia
December 13	*Saturday DNA!* Seminar, DNALC
December 15	Presentation at Garcia Center open house and science fair, Queens College, Flushing, New York
	Inside Cancer interview, Richard Stanley, The Albert Einstein College of Medicine, Bronx, New York
December 17	Site visit by Bruce Kovner, Chairman of the Board of Trustees of The Juilliard School, New York, New York
December 27	*Saturday DNA!* Seminar, DNALC

Sites of Major Faculty Workshops 1985–2003

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

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	**Foothill College, Los Altos Hills**	**1997**
	University of California, Davis	1986
	San Francisco State University	**1991**
	University of California, Northridge	**1993**
	Canada College, Redwood City	1997
	Pierce College, Los Angeles	**1998**
	California Lutheran University, Thousand Oaks	1999
	Laney College, Oakland	1999
	California State University, Fullerton	**2000**
	Salk Institute for Biological Studies, La Jolla	2001
	Contra Costa County Office of Education, Pleasant Hill	2002
	Harbor-UCLA Research & Education Institute, Torrance	2003
COLORADO	Colorado College, Colorado Springs	1994
	United States Air Force Academy, Colorado Springs	**1995**
	University of Colorado, Denver	1998
CONNECTICUT	Choate Rosemary Hall, Wallingford	1987
DISTRICT OF COLUMBIA	**Howard University**	**1992,1996**
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
	CityLab, Boston University School of Medicine	1997
	Dover-Sherborn High School, Dover	1989
	Randolph High School	1988
	Winsor School, Boston	1987
	Boston University	**1994,1996**
	Whitehead Institute for Biomedical Research, Cambridge	2002
	Biogen, Cambridge	2002
MICHIGAN	Athens High School, Troy	1989
MISSISSIPPI	Mississippi School for Math & Science, Columbus	1990,1991
MISSOURI	Washington University, St. Louis	1989
	Washington University, St. Louis	**1997**
	Stowers Institute for Medical Research, Kansas City	2002
NEW HAMPSHIRE	St. Paul's School, Concord	1986,1987
	New Hampshire Community Technical College, Portsmouth	**1999**
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
	DeWitt Middle School, Ithaca	*1991,1993*
	DNA Learning Center	1988–1995, 2001–2003
	DNA Learning Center	**1990,1992, 1995,2000**
	DNA Learning Center	*1990–1992*
	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
	Orchard Park Junior High School	*1991*
	Plainview–Old Bethpage Middle School	*1991*
	State University of New York, Purchase	1989
	State University of New York, Stony Brook	1987–1990
	Titusville Middle School, Poughkeepsie	*1991,1993*
	Wheatley School, Old Westbury	1985
	US Military Academy, West Point	**1996**
	Stuyvesant High School, New York	1998-1999
	Trudeau Institute, Lake Saranac	2001
	Rockefeller University, New York	2003
NORTH CAROLINA	North Carolina School of Science, Durham	1987
	CIIT Center for Health Research, Triangle Park	2003
OHIO	Case Western Reserve University, Cleveland	1990
	Cleveland Clinic	1987
	North Westerville High School	1990
OKLAHOMA	School of Science and Mathematics, Oklahoma City	1994
	Oklahoma City Community College	**2000**
	Oklahoma Medical Research Foundation, Oklahoma City	2001
OREGON	Kaiser Permanente-Center for Health Research, Portland	2003
PENNSYLVANIA	Duquesne University, Pittsburgh	1988
	Germantown Academy	1988
SOUTH CAROLINA	Medical University of South Carolina, Charleston	1988
	University of South Carolina, Columbia	1988
TEXAS	J.J. Pearce High School, Richardson	1990
	Langham Creek High School, Houston	1991
	Taft High School, San Antonio	1991
	Trinity University, San Antonio	**1994**
	University of Texas, Austin	**1999**
	Austin Community College-Rio Grande Campus	2000
	Southwest Foundation for Biomedical Research, San Antonio	2002
UTAH	University of Utah, Salt Lake City	1993
	University of Utah, Salt Lake City	**1998**
	University of Utah, Salt Lake City	**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
WASHINGTON	**University of Washington, Seattle**	**1993,1998**
	Fred Hutchinson Cancer Research Center, Seattle	1999, 2001
WEST VIRGINIA	Bethany College	1989
WISCONSIN	Marquette University, Milwaukee	1986,1987
	University of Wisconsin, Madison	1988,1989
	Madison Area Technical College	**1999**
	Blood Center of Southeastern Wisconsin, Milwaukee	2003
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	2001–2003
SWEDEN	Kristineberg Marine Research Station, Fiskebackskil	1995

Dolan DNA Learning Center 2003 Grants

Federal Grants		Term of Grant	2003 Funding
National Institutes of Health ELSI Research Program	Creation of an *Image Archive on the American Eugenics Movement*	3/98-3/04	$187,773
National Institutes of Health	Creation of *Inside Cancer*	1/01-12/03	$267,472
National Science Foundation	Developing and Disseminating New Laboratories on Plant Molecular Genetics and Genomics	2/03-1/06	$124,390
Non-Federal Grants			
Howard Hughes Medical Institute	Precollege Science Education Initiative for Biomedical Research Institutions	9/99-8/03	$118,666
Howard Hughes Medical Institute	*DNA Interactive* Education Program	1/02-6/04	$546,825
Pfizer Foundation	Leadership Institute in Human and Molecular Genetics	1/03-12/03	$80,382

The following schools each awarded a grant for the *Genetics as a Model for Whole Learning Program*:

Allen Christian School	$350	Levittown Union Free School District	$525
Bayshore Union Free School District	$1,920	Locust Valley Central School District	$13,130
Baldwin Union Free School District	$1,200	Long Beach City School District	$700
Bellmore Union Free School District	$2,550	Lynbrook Union Free School District	$1,030
Bellmore-Merrick Central School District	$12,400	Merrick Union Free School District	$960
Bethpage Union Free School District	$1,800	New York State School for the Deaf	$240
Bnos Bais Yaakov	$850	North Bellmore Union Free School District	$1,050
Commack Union Free School District	$2,131	Northport-East Northport Union Free School District	$360
Crestwood Country Day School	$350	North Shore Hebrew Academy	$425
Crotona Achievement Center	$75	Old Westbury School of the Holy Child	$2,115
DGK Parochial School	$125	Plainedge Union Free School District	$1,375
East Williston Union Free School District	$2,040	Port Washington Union Free School District	$700
Elwood Union Free School District	$3,400	Queens District #29	$41,025
Farmingdale Union Free School District	$2,585	Rockville Center Union Free School District	$7,020
Friends Academy	$3,790	Sand Creek Middle School	$1,492
Garden City Union Free School District	$9,765	Sayville Union Free School District	$480
Great Neck Union Free School District	$8,875	South Huntington Union Free School District	$425
Grover Cleveland Middle School	$960	St. Aiden School	$700
Half Hollow Hills Central School District	$5,250	St. Anne School	$350
Harborfields Central School District	$9,960	St. Edward the Confessor School	$2,650
Hebrew Academy of Nassau County	$850	St. Joseph School	$350
Hempstead Union Free School District	$350	St. Mary School	$590
Herricks Union Free School District	$1,750	St. Nicholas of Tolentine School	$350
Holy Family Regional School	$350	St. Peter's Kids	$175
Huntington Union Free School District	$480	Syosset Central School District	$25,775
Jericho Union Free School District	$7,025	Three Village Central School District	$1,475
Kings Park Central School District	$1,245	United Nations School	$700
Laurel Hill School	$350	West Babylon Union Free School District	$350
Lawrence Union Free School District	$7,010	Yeshiva Darchei Torah	$850
Lawrence Woodmere Academy	$240		

The following schools each awarded a grant for *Curriculum Study*:

Bellmore-Merrick Central High School District	$1,500	Locust Valley Central School District	$1,250
Bethpage Union Free School District	$2,350	Long Beach City School District	$1,100
Commack Union Free School District	$1,250	Oceanside Union Free School District	$1,100
East Meadow Union Free School District	$1,100	Portledge School	$1,250
Elwood Union Free School District	$1,100	Ramaz School	$2,350
Friends Academy	$2,350	Roslyn Union Free School District	$1,250
Half Hollow Hills Central School District	$2,350	Sachem Central School District	$1,250
Herricks Union Free School District	$1,100	South Huntington Union Free School District	$1,250
Lawrence Union Free School District	$1,250	Syosset Central School District	$1,100

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