

1994

DNA LEARNING CENTER



COLD SPRING HARBOR LABORATORY

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DNA LEARNING CENTER

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Time flies. It hardly seems possible, but it was ten years ago that Cold Spring Harbor Laboratory offered its first summer training course in recombinant DNA technology for high school faculty. The DNA Learning Center did not exist then, so the workshop was held in a classroom at the Wheatley School in Nassau County.

The course was not called *DNA Science*, as it is today. The title then, *Recombinant DNA for Beginners*, was borrowed from the 1971 record album, *Songs for Beginners*, by Graham Nash. This was Nash's first solo album after the split-up of Crosby, Stills, Nash, and Young—a band propelled into the public consciousness by Woodstock and in many ways emblematic of that awkward time in American life. Nash's album was composed largely of simple songs with which nearly any beginning guitar player or vocalist could easily tag along and so, in some sense, feel like a pop musician. Our course was likewise intended—a collection of relatively simple experiments that could make high school students feel like molecular biologists. In 1990, when our manuscript was formally printed, we opted for the more enduring title, *DNA Science*. This simple but catchy synopsis of molecular genetics—looking at biology through the lens of DNA—had been mentioned casually in conversation by Jim Watson. The name has stuck, because I now hear biology educators using the term DNA science in a generic sense.

The project to develop molecular genetic experiments for student use had its origin in an unlikely collaboration between Dave Micklos, then public affairs and development director at the Laboratory, and Greg Freyer, then a postdoctoral fellow in Richard Roberts' lab group. Beginning in 1984, Greg volunteered to prepare gels of *Lambda* restriction digests for Dave to show to school students who came for tours of the Laboratory. The stained gels were illuminated on a long-wavelength UV "black light" Dave found in a lab storeroom. This was a relic from the mid-1970s, when ethidium bromide staining was developed at Cold Spring Harbor by Phil Sharp, Bill Sugden, and Joe Sambrook. Specialized mid-wavelength transilluminators were not initially available; however, "black lights" were available for illuminating the posters that were a popular form of interior decoration for young people.

Students proved fascinated with those simple "DNA fingerprints" of the *Lambda* virus, and we began thinking about hands-on experiments that might be done in high school biology classes. At about the same time, Fran Roberts became superintendent of Cold Spring Harbor Schools and sent a letter to Jim Watson asking how the school district and the Laboratory could work together in education. Fran, who had just returned from a tour of duty at the National Endowment for the Humanities in Washington, D.C., suggested that we submit a joint



Greg Freyer (Left), Dave Micklos, and student during first *DNA Science* summer workshop in 1985

grant proposal to the newly resynthesized education directorate of the National Science Foundation (NSF). Our proposal to develop a workshop to introduce high school teachers to recombinant DNA was turned down by NSF in 1984.

After this setback, local educators Mike Glennon and Ed Tronolone suggested what seemed a preposterous idea—to get several well-heeled school districts of Long Island to each contribute \$10,000 toward teacher training and equipment purchase. By January 1985, \$60,000 had been raised from six charter districts of the Cold Spring Harbor Curriculum Study, and we committed to have the first training workshop ready for summer.

The workshop would be based upon a laboratory sequence conceived by Greg and contained in a slim "manuscript" consisting of 10–12 pages of lab notes comprehensible only to a bench scientist. Happily, Rich Roberts gave Dave a half-counter of bench space at which the labs could be fleshed out before being loosed on high school teachers. In the spring, the labs were first tested with teachers during afternoon sessions at Cold Spring Harbor High School. Unfortunately, the pivotal lab involving the recombination of ampicillin- and kanamycin-resistant genes did not work. Anjun Bagwat, another postdoc in Rich Roberts' lab, solved that problem simply by including a recovery at 37°C prior to plating on kanamycin. By summer, every experiment worked well, and we conducted the first full-scale workshop at the Wheatley School in Williston Park.

Our horizons expanded in 1986, when we obtained our first real grant from Citibank to purchase and equip the first Vector Mobile DNA Laboratory. That summer, we perfected our capability for long-range instruction, conducting workshops in Massachusetts, New Hampshire, Wisconsin, Illinois, Chicago, and California. Our first NSF grant in 1987 allowed us to expand our national program and set this pattern of summer training that has extended over the ensuing years. Also in 1987, we further increased our reach when we joined with Carolina Biological Supply Company to formally publish the labs and to develop teaching kits to support wider dissemination of the *DNA Science* labs. This fruitful collaboration was brokered by Neil Patterson, the dean of modern biochemistry and molecular biology publishing, who, among many accomplishments, had published Jim Watson's epic *Molecular Biology of the Gene*.

The development of *DNA Science* is one of the first examples of bench molecular biologists making a substantive commitment to help bring biology education into the gene age. Although this educational role is now accepted and legitimized at high levels of the biological research establishment, this was not the case in 1984, especially at a "pure" science place like Cold Spring Harbor Laboratory. At that time, research biologists were generally thought to have only one responsibility—to the bench. Rich Robert's blessing for Greg to participate in the project, donating enzymes and lab supplies, and providing lab space for Dave were almost without precedent at the time.

But Rich's help also made good sense. During the 1970s, prior to the advent of biotechnology supply houses, the Roberts lab had been a major source of restriction enzymes. During that period, his group isolated approximately half of known restriction enzymes, which were made available free of charge. Researchers visiting Cold Spring Harbor for symposia and courses would literally line up outside his lab for samples of enzymes with new cutting specificities. So, just as the Roberts lab had helped popularize the use of restriction enzymes in research, it also encouraged their new use as educational tools. Our historical connection to Rich became even more precious, when in 1993 he was awarded the Nobel Prize for the codiscovery of RNA splicing.

Receipt of Key Grants

In July, we were awarded a 5-year grant of \$400,000 from the Howard Hughes Medical Institute through the new Precollege Science Education Initiative for Biomedical Research Institutions. The DNALC grant was the second largest of awards to 42 institutions. The Hughes program will support our ongoing work with local school districts to vertically integrate genetics instruction at the elementary, middle, and high school levels. Significant resources will also be used to provide intensive enrichment for minority students at several New York City schools and to link these resource-poor schools to Long Island schools with well-developed genetics education programs. The grant provides large-scale support for our *BioMedia* Computer Laboratory to model uses of high-level computing in biology education, including the *Student Allele Database*, which allows students to electronically submit personal DNA fingerprints and compare them with those of other students from around the world. Related collaborations with Helen Donis-Keller at Washington University, St. Louis, and John Kruper at the University of Chicago are also supported.

In October, we were notified that the NSF had approved 3-year funding of \$218,503 for "A Novel Mechanism for Introducing Human Genome Research in Freshman Biology Classes." Under the new project, to begin in 1995, college faculty will be trained to implement our polymerase chain reaction (PCR) experiment on human *Alu* insertion polymorphisms and to use the *Student Allele Database*. Twenty-four participants will attend each of four workshops per year held at sites around the country. Faculty from 2-year and minority institutions will be targeted in promotional mailings, and one workshop per year will be sited at a historically minority institution. This grant follows on 4 years of continuous funding from the Undergraduate Faculty Enhancement Program and complements our NSF training program for high school faculty.

Building Our Computational Capability

In the spring, we released the *Genetic Computer Arcade* through the Carolina Biological Supply Company. Developed by designer Sue Lauter, this animated and interactive computer "primer" helps students build mastery of genetics concepts and gives examples of real-life applications of modern genetic technology. The program can be played on virtually any Macintosh computer with a color monitor; CD-ROM, laser disk player, other devices, or specialized software *are not* needed. Each of five "chapters" incorporates photographs, animation, and scientific data. Modules include Gregor Mendel explaining his classic experiments with peas; "Gene" the DNA person demonstrating types and causes of mutations; and case studies illustrating forensic DNA fingerprinting, DNA diagnosis, and gene therapy. The programs build knowledge sequentially, with the introductory topics appropriate for bright elementary students and the more advanced topics appropriate for high school students.

With 3-year capital support from the Stone Foundation, we have been building a sophisticated computer network for staff and student use. Our local area network of 12 Macintosh Quadras in the *BioMedia* Laboratory and 4 Sun Sparcstations in the staff office are all linked through a Sun 10-30 server. However, it was becoming increasingly difficult for the Laboratory computer center to provide support for our substantial network, and we were unable to provide students regular access to the *BioMedia* Laboratory.

A scene from "Human Genetic Disease," one of five programs in the *Genetic Computer Arcade*



Robert Muratore (right) assists students in the *BioMedia* Computer Laboratory

This situation was remedied in July, with the arrival of full-time computational biologist, Robert Muratore. With a bachelor's degree in bioengineering from Johns Hopkins, a master's degree in mechanical and aerospace engineering from Princeton, and a doctorate in biophysics from Syracuse, Robert is exactly the hands-on sort of person we were seeking. Prior to joining our staff, Robert was on the faculty at SUNY Geneseo, where he developed a new biophysics program and taught computer science. His thesis research at Syracuse and post-doctoral work at the National Institutes of Health involved developing computer programs to image brain activity using antiprotons. Earlier work at the Space Studies Institute at Princeton and Hughes Aircraft Company included designing a fault-tolerant electronic interface for the *Galileo* planetary probe now en route to Jupiter.

Two events at year's end dramatically increased our computational capability. First, we took delivery of a Silicon Graphics Indigo2 workstation, a fast graphics terminal of the type used to create digital effects in movies such as *Jurassic Park*. The Silicon Graphics machine will allow us to begin work on *Journey to the Center of the Cell*, a recreation of a three-dimensional microspace of a cell based on electron micrographical data. Second, the DNALC was connected to the main Laboratory via a fiber optic cable. This linkage allows our Sun server to communicate at ethernet speeds with the Laboratory's *Phage* server. This provides us with extremely fast access to Internet and other international networks. To encourage student and faculty use of our computational facilities, we now schedule free Internet access on Thursday afternoon each week.

Also at year's end, plans were finalized for renovation of a computer/design office in the east basement, which will mark the completion of an 8-year effort to redevelop our 1925 school building as a modern science center. The office will house computational biologist Robert Muratore and designer Sue Lauter, as well as several interns. The space will facilitate a synthesis of these two functions, which will be increasingly important as we begin development of three-dimensional computer and video programs. The facility will become the command center for our local computer network, as well as our node on international networks. Under the new configuration, the *Multitorium*, *Bio2000* Teaching Laboratory, and research/prep laboratory will be added to the network.

NEW Carolina Exclusive

Polymerase Chain Reaction Kits

A revolution in molecular genetic analysis brings the power of PCR[®] into your classroom!



Now, an experiment to test Mendel's principles of heredity can be done in the laboratory. Students can learn about the power of PCR[®] by amplifying a specific DNA sequence. The kit includes all the materials you need to perform the experiment. The kit is easy to use and can be performed in a standard laboratory setting. The kit is also suitable for use in a classroom setting. The kit is a great way to introduce students to the power of PCR[®].

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Progress in Making PCR Widely Available to Biology Students

Although the revolutionary importance of polymerase chain reaction (PCR) was recognized by the 1993 Nobel Prize in Chemistry, the cost, biochemical complexity, and patent protection of the process have kept it beyond the reach of biology instruction. Believing that PCR offers the *only* practical means for students to examine their own DNA and the best means to introduce human molecular genetics, we have made it our business to remove the obstacles to its use in precollege and freshman college classes. Tangible evidence of success came in September with the release of the first educational PCR kits by Carolina Biological Supply Company, under license from Perkin-Elmer. One kit amplifies viral DNA using hand thermal cycling, and the other kit amplifies the D1S80 human polymorphism using automated cycling.

During the summer, we began to shift emphasis to the class of *Alu* insertion polymorphisms, which work brilliantly with the mouthwash/chelex extraction we advocate, show very little nonspecific amplification, and can be analyzed conclusively on agarose gels. *Alu* is a family of repeated DNA sequences, approxi-

Ad for PCR kits in Carolina Biological's Biotechnology catalog

mately 300 nucleotides in length, that have the ability to copy themselves and insert randomly throughout the genome. Some *Alu* elements have inserted so recently in evolutionary time that they have not been inherited with the same frequency by different groups of people. Such *Alu* insertions are termed dimorphic ("two forms") because chromosomes can be scored for the presence or absence of the insertion. Because *Alu* insertions at a particular chromosome locus have only two alleles (+ or -), they make simple case studies for studying population genetics.

Robert Muratore worked quickly to develop a prototype *Student Allele Database* that allows students to tabulate *Alu* insertion data and test Hardy-Weinberg Equilibrium. The database also contains *Alu* insertion data from several Mendelian populations in Africa, Greenland, Sardinia, and the Caribbean. Users can compare any two populations using contingency Chi-square and calculate simple genetic distances. Initially, the database template and test data are available on diskette or can be downloaded from Genentech's *Access Excellence* gateway on America Online. Soon, Internet users will be able to access the database through our World Wide Web home page and manipulate data in real time.

Robert also led design development of a inexpensive thermal cycler, which we hope will make PCR accessible to high school and college instructors. The device consists of computer software and an analog-digital interface that cycles temperature in a Plexiglas reaction vessel by alternately activating an immersion heater and a solenoid valve controlling cold water flow. Water-flow regulation was simplified and a custom analog-digital controller was designed to receive commands from both Macintosh and PC computers. In collaboration with John Kruper, head of academic computing of the Biological Science Division of the University of Chicago, development of a much-improved Macintosh controller is nearing completion.

Training Workshops Reach Faculty and Opinion Leaders Nationwide

With funding from the National Science Foundation, we continued our tradition of offering high-level lab training to high school and college faculty. Dave Micklos took the standard-bearing *DNA Science* far afield, reaching 100 high school teachers at workshops in Oklahoma City, Colorado Springs, Moscow (Idaho), and San Juan. Mark Bloom instructed 47 college faculty at *Advanced DNA Science* workshops in San Antonio and Boston. The *Leadership Institute in Human and Molecular Genetics*, also known as DNA Boot Camp, drew together top high school faculty representing 22 states, Sweden, and Australia. In addition to practical laboratory and computer work, the institute included seminars on an array of topics by Laboratory scientists and visiting faculty:

Jack Ballantyne, Suffolk County Examiner's Office: Forensic DNA typing.

Susan Brady, Lawrence Hall of Science: Partnerships.

Xiaodong Cheng, Cold Spring Harbor Laboratory: Structure of DNA/*Hha*I methylase cocrystal.

Seth Grant, Columbia University: Molecular basis of memory.

Fred Gillam, Sachem High School: Laboratory program in molecular genetics.

John Horton, Cold Spring Harbor Laboratory: X-ray crystallography.

Paul Hough, Brookhaven National Laboratory: DNA-binding proteins.

John Kruper, University of Chicago: Computational biology.

Ruji Kobayashi, Cold Spring Harbor Laboratory: High-performance liquid chromatography and peptide synthesis.
 Gerry Latter, Cold Spring Harbor Laboratory: Two-dimensional protein electrophoresis.
 Elaine Lawson, Institute of Medicine: Assessing genetic risks.
 Sue Levi-Pearl, Tourette Syndrome Association: Genetic disease support groups.
 Dan Marshak, Cold Spring Harbor Laboratory: Protein kinases and mass spectrometry.
 Dick McCombie, Cold Spring Harbor Laboratory: DNA sequencing.
 Rick Michitsch, Oncogene Science: Expression screening for therapeutic agents.
 Bruce Stillman, Cold Spring Harbor Laboratory: Research highlights.
 Spencer Teplin, Cold Spring Harbor Laboratory: DNA synthesis.
 Tim Tully, Cold Spring Harbor Laboratory: Genes and behavior.
 James Watson, Cold Spring Harbor Laboratory: Open question and answer.
 Jan Witkowski, Banbury Center: DNA screening and diagnosis.

With funding from the Department of Energy, we continued our collaboration with Banbury Center to introduce nonresearchers to the science behind the Human Genome Project. In the past, the project targeted "opinion leaders" in federal agencies, the media, education, law, and ethics who influence policy and education. The 1994 workshop drew education directors from 15 hospitals in New York State, with the expectation that they will begin the process of educating doctors about the growing impact of molecular genetics in medicine. In addition to an experiment to illustrate the basis of DNA diagnosis and background briefings, participants heard high-level seminars about topics on the interface of molecular genetics, medicine, and society:

Susan Airhart, Oncor Science: Cytogenetics in the age of DNA.
 Charles Link, Iowa Methodist Hospital: Human gene therapy trials.
 Philip Reilly, Shriver Center for Mental Retardation: Future of genetic testing and screening.
 Marsha Saxton, Massachusetts Office on Disability: Genetics and cultural attitudes to disability.
 Rudolph Tanzi, Massachusetts General Hospital: Molecular genetics and biology of Alzheimer's disease.
 Tim Tully, Cold Spring Harbor Laboratory: Genetics and behavior.
 Patricia Ward, Baylor College of Medicine: DNA-based diagnosis for human genetic diseases.

Expanding Hands-on Opportunities for Local Students

When we first developed the *DNA Science* curriculum, we were one of only a handful of institutions offering laboratory training in molecular genetics for precollege faculty. During the last decade, we have maintained the only continuously funded program operating on a nationwide scale. Our expertise at administering off-site workshops has provided a "jump-start" for local initiatives in many states. However, as more and more local universities have accepted the challenge to provide lab training for teachers, the need for off-site workshops has decreased. Fortunately, at the same time, demand for local programs and use of our excellent facilities is increasing. So we find that, after securing our reputation

through national programs, we are now devoting more effort to fostering innovative biology instruction in the school systems in our own backyard.

Realizing that systematic genetics education needs to begin when children are still forming fundamental attitudes and behaviors, we are focusing our effort at the middle-school level (grades 5–8). The flagship of our commitment to younger learners is *Genetics as a Model for Whole Learning*, which uses genetics as a paradigm for integrated learning and which incorporates concepts across disciplines and relates science to the student's life and culture. Working almost single-handedly, Education Manager Jane Conigliaro has aided faculty at 15 schools to introduce genetics modules in their elementary and middle school classes, reaching 1590 students in 1994. We anticipate that these students will provide an eager audience for the advanced genetics activities currently available at the high schools in their districts. Thus, in the small school districts of Long Island, we are beginning to see working models of science education for the gene age, incorporating hands-on learning about genetics at several stages in child and adolescent development.

The *Bio2000* Laboratory was kept very busy during the academic year. Labs on bacterial transformation, DNA restriction analysis, and human DNA fingerprinting were performed by 3180 high school students, and experiments on Mendelian genetics, cell study, and DNA extraction were performed by 780 5th–7th graders. This was a 24% increase in total lab visits over 1993, made possible through the excellent instruction offered by part-time instructors Flavio Della Seta, Diane Esposito, Diane Jedlicka, and Malissa Hewitt. The *Great Moments in DNA Science* Honors Student Seminar Series, now in its 10th year, continued to be a popular element of our annual calendar of events, drawing the attendance of 575 local students and teachers. Speakers and topics were:

Greg Freyer, Columbia University: Fixing DNA.

Tim Tully, Cold Spring Harbor Laboratory: Genes and memory.

Xiaodong Cheng, Cold Spring Harbor Laboratory: A surprising structure of DNA.

We continued to expand summer learning opportunities for local students, thanks in part to additional venues at Portledge School (Locust Valley), Central Islip School, Roslyn Middle School, and the American Museum of Natural History. High school students including 233 minority students received laboratory training during three sessions of *DNA Science*. Eight sessions of *Fun With DNA* served a total of 159 elementary students, including 74 minority students. Three sessions of the workshop *World of Enzymes* attracted 62 students.

Multimedia and Exhibit Programs

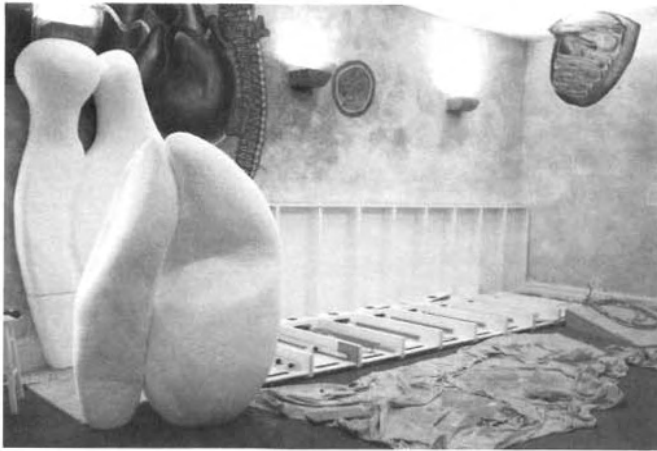
Although we devote our major effort to curriculum development and lab instruction, we are also committed to providing stimulating multimedia presentations and exhibits for our visitors. We were happy to find that Cablevision's multimedia show, *Long Island Discovery*, drew 15,000 viewers during its first year of operation, more than twice the number of DNALC visitors prior to the show's opening in October 1993.

By year's end, the staff was focused on the development of three new exhibits to fill renovated galleries on the main level: *Story of a Gene*, *The World of Barbara McClintock*, and the *Cold Spring Harbor Nobels*. *Story of a Gene* is a comprehensive presentation on the biochemistry, physiology, medical uses, and

Xiaodong Cheng presents his research to advanced biology high school students



Karin Glaizer and Elizabeth Woerner present "Linda," a study of brain tumor gene therapy for the *World of Enzymes* summer workshop



(Below left) Denise Sauer puts finishing touches on exhibit entry sig. (Left) The Walk of Life construction in progress. (Right) Malissa Hewitt, lab instructor turned painter, works on a dungeon wall

social aspects of human growth hormone (HGH). The exhibit will encourage visitors to integrate microscopic through macroscopic perspectives, including (1) expression of the HGH gene, as illustrated in the *Cellarium* mural; (2) physiology of human growth; (3) the danger of isolating HGH from human cadavers and the link with kuru and Creutzfeldt-Jakob disease; and (4) ethical issues arising from ready availability of the hormone produced by recombinant DNA technology. The exhibit employs two- and three-dimensional displays, computer multimedia, video, and audio—many elements that will encourage visitor interaction.

The World of Barbara McClintock, being developed in cooperation with the Public Affairs Department, will recreate McClintock's laboratory using equipment and personal effects saved after her death. The object is to provide visitors with a glimpse of the day-to-day intellectual life of an extraordinary individual. *Cold Spring Harbor Nobels* shows the prizes and highlights the common thread of Nobel-winning experiments by Al Hershey, James Watson, Barbara McClintock, and Richard Roberts. All three exhibits will be geared to a level appropriate for bright elementary students and will also be appropriate for the general public. Curriculum guides, including vocabulary, questions, and readings, will help students get the most out of their exhibit visit and follow up on their interests.

Corporate Advisory Board

In the fall, we bid farewell to Corporate Advisory Board Chairman Doug Fox, when he left his position at Times Mirror to become Chief Operating Officer of Landmark Communications of Norfolk, Virginia, which owns the Weather Channel. Under Doug's leadership, the Corporate Advisory Board has become an effective advocate for the DNALC, raising substantial unrestricted annual funds and increasing our visibility in the Long Island business community. Our disappointment at Doug's departure was muted by our good luck that the chairmanship was taken over by Rick Clark. A partner at Price Waterhouse, Rick showed his commitment to our cause when he worked closely with Doug to organize the first annual Cold Spring Harbor Laboratory Golf Tournament. Held at Piping Rock Club on June 7, the tournament netted \$47,750, which was added to



Dave Micklos with Corporate Advisory Board members (from left to right) Arthur Herman, Rick Clark, Pat Peterson, Michael Aboff and Michael Vittorio

the DNALC Annual Fund. Rick's service to the Laboratory began in 1993 when he hosted the CSHL Association outreach event at the Manhattan office of Price Waterhouse. His connection to us is strengthened through his wife Jill, who is associate development director for the Laboratory.

The Corporate Advisory Board draws strength from Vice-Chairman Gary Frashier, President and CEO of Oncogene Science, who is our link to the growing biotechnology industry on Long Island. Other members of the executive committee represent the gamut of Long Island businesses: Rocco Barrese, founding partner at the patent law firm Dilworth and Barrese; Howard Blankman, founder of the public relations firm Howard Blankman Inc.; Tom Calabrese, managing director at NYNEX; Bob Diller, Vice President of the scientific equipment firm Brinkmann Instruments; Art Herman, chairman of A.D. Herman Construction; Pat Peterson, President of the realty company Daniel Gale Agency; and Peter Schiff, general partner of Northwood Ventures.

Staff and Interns

Administering our rigorous schedule of student field trips, student summer workshops, teacher-training institutes, and various follow-up activities has become an increasingly complicated task. Each program typically requires an informational mailing of 400 or more pieces, answering queries, taking reservations, processing applications, sending confirmations, and tracking payments. Many programs take place off-site and require coordination with a local organizer; several programs require yearly mail surveys. Five part-time staff and five interns provide cost-effective support and instruction but further complicate scheduling. Since her arrival at the beginning of the year, Judy Cumella has made herself indispensable in choreographing this complex dance of people and activities. She functioned single-handedly during parts of the summer when Mark and Dave were teaching off-site and Sue was out on maternity leave. In recognition of her key organizational role and the increasingly complicated nature of our activities, Judy was promoted to Program Coordinator in the fall.

The recruitment of part-time lab instructor Malissa Hewitt enabled us to offer daily afternoon labs for elementary and middle-school students. Malissa has an undergraduate degree in early childhood/elementary education and has taught elementary science at the School of the Holy Child in Old Westbury and kindergarten at the Gardens Schools. She is currently working on her master's degree in secondary biology education.

Malissa Hewitt and Stacey Trotter organize supplies in the *Bio2000* Teaching Laboratory



We continued to get excellent laboratory, computational, and design support from interns drawn from neighboring high schools and colleges. Designer Sue Lauter was assisted by Donna Conversano and Denise Sauer. An art student at the New York Institute of Technology, Donna had participated in the painting of the Cellarium Mural in summer 1993. During the academic year, she added finishing touches to the 1993 building renovation, including hand-lettering the names of 35 Nobel Laureates in genetics whose names appear on the Multi-torium frieze. Donna and Denise overpainted areas of the Cellarium mural to more accurately portray the cellular expression of human growth hormone (HGH), including the addition of transcriptional activators, signal recognition apparatus, and barrel depiction of HGH protein. Denise is an art student at SUNY Farmingdale.

Computational biologist Robert Muratore was assisted by Chris Como (Cold Spring Harbor High School) and Mark Teoh (Rice University). In addition to helping to maintain our growing computer network, each worked on multimedia projects for the *Story of a Gene* exhibit. Chris has developed an animated introduction by "Gene" the gene person, and Mark has assembled a software package to create a "morph" illustrating human growth.

The laboratory instructional staff was ably assisted by high school interns Andy Diller (Sachem), Ken Bassett (Massapequa), Jessica Hinton (Huntington), and Jermel Watkins (Central Islip). In the fall, we bid farewell to Andy, who began his freshman year at Rutgers, and welcomed Jermel, whose father Jerry is a biology instructor at Central Islip High School. Jerry was a participant in the NSF-sponsored *Leadership Institute* and coordinates our effort to develop Central Islip as the hub of an Instructional Resource Cluster serving the underprivileged students in Brentwood and Wyandanch. Assisting at *Fun With DNA* summer camps were lab aides Tara Marathe (Colby College), Daryn Berger (Walt Whitman High School), Andrea Conigliaro (St. Anthony's High School), and Michael Conigliaro (Cold Spring Harbor High School).

Publications

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- Bloom, M., G. Freyer, and D. Micklos. 1994. *Laboratory DNA science: An introduction to recombinant DNA technology and methods of genome analysis*. Benjamin/Cummings, Redwood, California (in press).
- Micklos, D. 1994. Go with the odds: Believe DNA. *Newsday*. September 27, 1994.
- Micklos, D. 1994. Genetic testing: An educational imperative to our schools. In *Assessing genetic risks: Implications for health and social policy*, vol. 2. National Academy Press, Washington, D.C.
- Micklos, D. and J. Kruper. 1994. Genetics education in American schools. *Biotechnology Education* **4**: 2.

1994 Workshops, Meetings, and Collaborations

January 19	Long Island Partnership Meeting, DNALC Corporate Advisory Board Meeting, DNALC
January 22	Site visit by David Hicks, St. Paul's School, Concord, New Hampshire
January 26–28	National Science Foundation Grant Review, Washington, D.C.
March 5–6	National Science Foundation Follow-up Workshop, <i>Advanced DNA Science</i> , University of Puerto Rico, Rio Piedras
March 8–10	National Institutes of Health Grant Review, Washington, D.C.
March 12–13	National Science Foundation Follow-up Workshop, <i>Advanced DNA Science</i> , University of Washington, Seattle
March 17	Laboratory for SEED Program, SUNY, Old Westbury, DNALC
March 22–24	Carolina Biological Supply Company, Burlington, North Carolina
March 30	Corporate Advisory Board Meeting, DNALC
March 31–April 1	National Science Teachers Association Meeting, Los Angeles, California
April 5	<i>Access Excellence</i> Advisory Committee, Genentech, Inc., South San Francisco, California
April 14	National Institute of Social Sciences Lecture, Harvard Club, New York, New York <i>Great Moments In DNA Science</i> Honors Student Seminar, DNALC
April 20	<i>Great Moments In DNA Science</i> Honors Student Seminar, DNALC
April 21–23	Department of Energy Workshop, <i>Human Genetics and Genome Analysis</i> , DNALC and Banbury Center
April 27–28	National Science Foundation Grant Review, Ann Arbor, Michigan
April 30–May 1	Department of Education Follow-up Workshop, <i>Advanced DNA Science</i> , Golden West College, Los Angeles, California
May 3	<i>Great Moments In DNA Science</i> Honors Student Seminar, DNALC
May 12–14	National Science Foundation Grant Review, Washington, D.C.
May 17	Hutton House Lecture, Long Island University, Old Westbury, New York
May 20	New York Biotechnology Association Meeting, DNALC
May 24	Hutton House Lecture, DNALC
June 6–10	National Science Foundation Workshop, <i>DNA Science</i> , Colorado College, Colorado Springs
June 13–17	National Science Foundation Workshop, <i>DNA Science</i> , Oklahoma School of Science and Mathematics, Oklahoma City
June 13–24	National Science Foundation Workshop, <i>Advanced DNA Science</i> , Boston University, Boston, Massachusetts
June 20–24	National Science Foundation Workshop, <i>DNA Science</i> , University of Idaho, Moscow
June 27–July 1	<i>DNA Science</i> Workshop, DNALC
July 1	Site visit by Laurence Smaje, Wellcome Trust, London, England
July 4–8	<i>World of Enzymes</i> Workshop, Portledge School, Locust Valley, New York
July 4–29	National Science Foundation <i>Leadership Institute</i> , DNALC
July 11–15	<i>Fun With DNA</i> Workshop, Portledge School, Locust Valley, New York
July 25–28	<i>Fun With DNA</i> Workshop, Portledge School, Locust Valley, New York <i>Fun With DNA</i> Minority Workshop, American Museum of Natural History, New York, New York
August 1–5	National Science Foundation Workshop, <i>DNA Science</i> , University of Puerto Rico, Rio Piedras <i>Fun With DNA</i> Workshop, DNALC
August 1–12	National Science Foundation Workshop, <i>Advanced DNA Science</i> , Trinity University, San Antonio, Texas
August 8–12	<i>Fun With DNA</i> Workshop, DNALC <i>Fun With DNA</i> Minority Workshop, Roslyn Elementary School, New York

August 15-19	<i>Fun With DNA</i> Minority Workshop, American Museum of Natural History, New York
August 18-19	<i>Fun With DNA</i> Minority Workshop, DNALC
August 22-26	Advanced Placement Workshop, Stanford University, Palo Alto, California
August 29-Sept. 2	<i>World of Enzymes</i> Workshop, DNALC
September 12-14	<i>DNA Science</i> Workshop, DNALC
September 22	<i>Decade of PCR</i> Meeting, CSHL
September 20	Seminar, CSHL Association, DNALC
September 26-30	Site visit by Helen Donis-Keller Laboratory, Washington University Medical School, St. Louis, Missouri
October 13	World Health Organization Workshop, <i>DNA Science</i> , University of Panama, Panama City
October 17	Site visit by Treopia Washington, Columbus Center, Baltimore, Maryland
November 2	Corporate Advisory Board Meeting, DNALC
November 12-13	Seminar, Adelphi University, Garden City, New York
November 12-17	National Science Foundation Follow-up Workshop, <i>DNA Science</i> , Oklahoma School of Science and Mathematics, Oklahoma City
November 16-19	Department of Energy Contractor's Meeting, Santa Fe, New Mexico
December 8	National Association of Biology Teachers Meeting, St. Louis, Missouri
December 9-10	Laboratory Seminar, Theodore Roosevelt American Inn of Court, DNALC
December 12	National Science Foundation Follow-up Workshop, <i>DNA Science</i> , University of Puerto Rico, Rio Piedras
	<i>Women In Science and Engineering Laboratory</i> , DNALC

Sites of Major 3-10-day Faculty Workshops 1985-94

KEY: High School
College
Middle School

ALABAMA	University of Alabama, Tuscaloosa 1987, 1988, 1989, 1990
ARIZONA	Tuba City High School 1988
ARKANSAS	Henderson State University, Arkadelphia 1992
CALIFORNIA	University of California, Davis 1986 San Francisco State University 1991 University of California, Northridge 1993
COLORADO	Colorado College, Colorado Springs 1994
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
GEORGIA	Fernbank, Inc., Atlanta 1989 Morehouse College, Atlanta 1991
HAWAII	Kamehameha Secondary School, Honolulu 1990
ILLINOIS	Argonne National Laboratory 1986, 1987 University of Chicago 1992
INDIANA	Butler University, Indianapolis 1987
IDAHO	Univeristy of Idaho, Moscow 1994
IOWA	Drake University, Des Moines 1987
KENTUCKY	Murray State University 1988 University of Kentucky, Lexington 1992 Western Kentucky University 1992
LOUISIANA	Jefferson Parish Public Schools, Harvey 1990 John McDonogh High School, New Orleans 1993

MANITOBA	Red River Community College, Winnipeg 1989
MARYLAND	Annapolis Senior High School 1989 McDonogh School, Baltimore 1988 Montgomery County Public Schools 1990-92 St. John's College, Annapolis 1991
MASSACHUSETTS	Beverly High School 1986 Dover-Sherborn High School, Dover 1989 Randolph High School 1988 Winsor School, Boston 1987 Boston University 1994
MICHIGAN	Athens High School, Troy 1989
MISSISSIPPI	Mississippi School for Math & Science, Columbus 1990-91
MISSOURI	Washington University, St. Louis 1989
NEW HAMPSHIRE	St. Paul's School, Concord 1986, 1987
NEVADA	University of Nevada, Reno 1992
NEW YORK	Albany High School 1987 Bronx High School of Science 1987 Columbia University, New York 1993 Cold Spring Harbor High School 1985, 1987 <i>DeWitt Middle School, Ithaca 1991, 1993</i> DNA Learning Center 1988-94 DNA Learning Center 1990, 1992 <i>DNA Learning Center 1990-92</i> <i>Fostertown School, Newburgh 1991</i> Huntington High School 1986 Irvington High School 1986 <i>Junior High School 263, Brooklyn 1991</i> <i>Lindenhurst Junior High School 1991</i> <i>Orchard Park Junior High School 1991</i> <i>Plainview-Old Bethpage Middle School 1991</i> State University of New York, Purchase 1989 State University of New York, Stony Brook 1987, 1988, 1989, 1990 <i>Titusville Middle School, Poughkeepsie 1991, 1993</i> Wheatley School, Old Westbury 1985
NORTH CAROLINA	North Carolina School of Science, Durham 1987
OHIO	Case Western Reserve University, Cleveland 1990 Cleveland Clinic 1987 North Westerville High School 1990
OKLAHOMA	School of Science and Mathematics, Oklahoma City 1994
PENNSYLVANIA	Duquesne University, Pittsburgh 1988 Germantown Academy 1988
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
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
UTAH	University of Utah, Salt Lake City 1993

VERMONT

University of Vermont, Burlington 1989

VIRGINIA

Jefferson School of Science, Alexandria 1987

Mathematics and Science Center, Richmond 1990

WASHINGTON

University of Washington, Seattle 1993

WASHINGTON, DC

Howard University 1992

WEST VIRGINIA

Bethany College 1989

WISCONSIN

Marquette University, Milwaukee 1986, 1987

University of Wisconsin, Madison 1988, 1989

WYOMING

University of Wyoming, Laramie 1991

DNA LEARNING CENTER

<i>Grantor</i>	<i>Program/Principal Investigator</i>	<i>Duration of Grant</i>	<i>1994 Funding*</i>
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FEDERAL GRANTS

NATIONAL SCIENCE FOUNDATION

A Two-part program to Develop and Support Nationwide Corps of Human & Molecular Genetics Resource Teachers at the Secondary Level, Mr. Micklos		4/93 - 3/96	283,918
Laboratory-based Instruction in Molecular & Human Genetics for Teaching Faculty, Dr. Bloom		5/93 - 4/95	291,275

U.S. DEPARTMENT OF EDUCATION

College Faculty Enhancement Dr. Bloom		1991 - 1994	87,336
<i>Training Support</i> Howard Hughes Medical Institute	Precollege Science Education Initiative for Biomedical Research Institutions	7/94 - 6/99	80,000 *

NONFEDERAL GRANTS

Harweb Foundation	Core Support	1994	1,000
Howard Hughes Medical Institute	High School Faculty Enhancement	1994	42,393
New York State Legislature	Middle School Program	1994	75,000
Stone Foundation	Equipment	1994	64,412
E.S. Webster Foundation	Core Support	1991 - 1994	20,000
Weezie Foundation	Exhibit	1991 - 1994	9,886

The following schools each awarded a grant of \$5,000 in 1994 for the Genetics as a Model for Whole Learning Program:

Great Neck Public Schools	Jericho Union Free School District
Half Hollow Hills Central School District	Locust Valley Central School District

The following schools awarded a grant for Curriculum Study in 1994 of \$850:

Commack Union Free School District	Massapequa Union Free School District
East Williston Union Free School District	Northport-East Northport Union Free School District
Garden City Union Free School District	North Shore Central School District
Great Neck Public Schools	Oyster Bay-East Norwich Central School District
Half Hollow Hills Central School District	Plainedge Union Free School District
Harborfields Central School District	Portledge School
Herricks Union Free School District	Port Washington Union Free School District
Island Trees Union Free School District	Roslynm Public Schools
Jericho Union Free School District	Sachem Central School District
Lawrence Union Free School District	South Huntington Union Free School District
Locust Valley Central School District	Syosset Central School District
Manhasset Union Free School District	

of \$1,500:

East Meadow Union Free School District

of \$2,000:

Ramaz School

* New Grants Awarded in 1994

+ Includes direct and indirect cost

DNALC Corporate Advisory Board Annual Fund

One of the objectives of the Corporate Advisory Board of the DNA Learning Center is to provide a sustainable level of annual funding for Learning Center programs. As a means of reaching this objective, the first annual Cold Spring Harbor Laboratory Golf Tournament was held in June 1993, with the proceeds benefitting the DNA Learning Center.

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Total **\$ 43,250**

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Total **\$ 47,750**