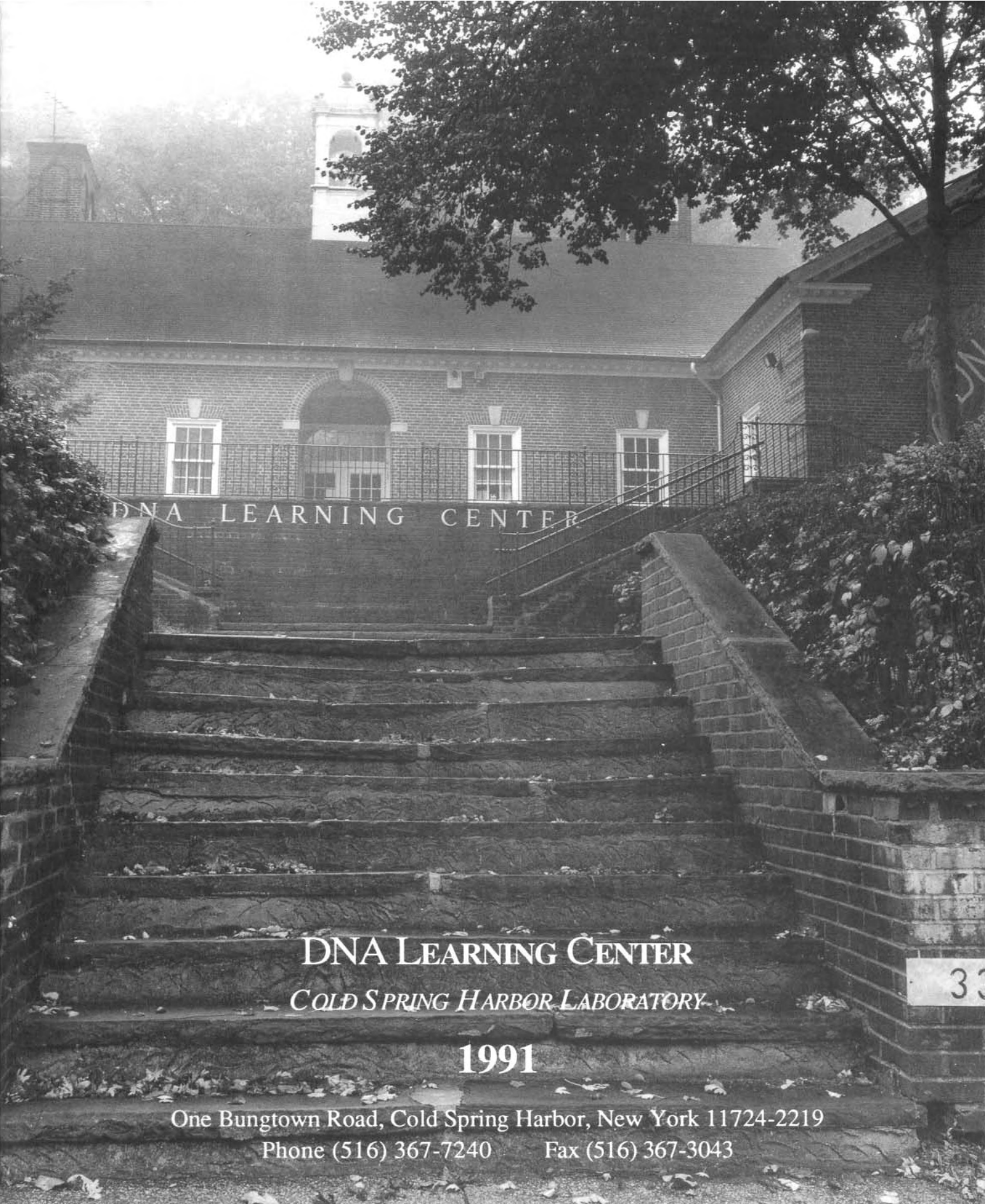

DNA LEARNING CENTER

COLD SPRING HARBOR LABORATORY

1991

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DNA LEARNING CENTER

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It has now been seven years since we began introducing precollege students and teachers to the intellectual challenge of molecular genetics. Our goal has always been to give students and teachers a view of "the cutting edge" of biological research and a base of knowledge that allows them to follow new developments on their own. With its assemblage of young enthusiastic researchers and visiting scientists from all corners of the globe, Cold Spring Harbor Laboratory is an ideal place from which to look into the future of biology. We, at the DNA Learning Center (DNALC), endeavor to exploit this unique vantage point to help direct the future of biology education. We have clung stubbornly to the notion that students should always be given the chance to experience the fun of biology—which is doing experiments. So, much of our effort has been devoted to finding safe ways for students to successfully perform experiments that closely parallel those done by research biologists.

When we initiated our teacher-training activities in 1985, we were one of only a very few research institutions in the nation that had made a substantive commitment to help precollege educators bring biology teaching into the gene age At that time, even reasonable people could dismiss our emphasis on genetics as too narrow or appropriate only for the upper echelon of advanced students. However, there is now growing awareness that genetic literacy is an essential element of basic health education and cultural literacy for *all* young people.

There can be no doubt that the Human Genome Project has accelerated the pace of research that is propelling our culture into a brave new world, where DNA diagnosis can detect serious disease well in advance of symptoms, where defective genes can be replaced by healthy ones, where scantron machines identify individuals by reading the bar code of their DNA profiles, and where criminals cannot afford to leave even a few of their own cells at a crime scene. It promises to be a world of triumph over genetic disease and crime, but also one fraught with new questions of personal and social responsibility:

- How will individuals deal with the knowledge that they harbor genes that predispose them to crippling or painful diseases?
- Should screening for certain genetic diseases or conditions be mandatory?
- Who should have access to personal genetic profiles?
- Will employers and insurance companies be permitted to use genetic data to exclude individuals from jobs or insurance?
- Will prospective parents be permitted to pick and choose among in vitro fertilized embryos for those with the "best" genes?

DNALC staff David Micklos, Jane Conigliaro, Sandra Ordway, Margaret Henderson, Mark Bloom, and Susan Lauter in front of new exhibit, *Eye on the Prizes*. Jane and Mark display plans for the DNA Learning Center addition.

The Growth and Problems of Genetics Education

When we began our efforts in genetic literacy, the Education Directorate of the National Science Foundation (NSF) was just arising, phoenix-like, after its disbandment under the Reagan administration in 1982–1984. (The NSF Education Directorate traditionally is the largest single funder of science education in the U.S.) There was little money to go around, and we were thankful in 1986 to receive the first of several NSF grants for our teacher-training programs. By the end of the decade, funding for the Education Directorate had risen to its highest level in history ($278 million). Funding for NSF, as well as other federal funding agencies, is likely to remain at high levels throughout the 1990s, given the charge of the President's *America 2000* Program, "By the Year 2000, U.S. students will be first in the world in science and mathematics achievement." Private foundations have also initiated major science education initiatives, including the Howard Hughes Medical Institute, the Pew Memorial Trust, and the Johnson Foundation. Genetics education has been among the beneficiaries of the dramatic increase in funding, both federal and private.

By 1991, the world of biotechnology and genetics education had become sufficiently large that the NSF convened a conference for leaders in the field, which filled a conference facility at the University of Wisconsin at Madison. It was gratifying to see the large number of creative educators now involved in biotechnology/genetics education—quite a few of these educators had been trained through the DNALC's *DNA Science* Workshops, had used our *DNA Science* text,

and had in some way modeled their programs after ours. The sense of shared accomplishment and consensus on key issues was amazing. There was unanimous agreement that biotechnology is not just a "flash in the pan" topic, but an opportunity to integrate concepts from biology, chemistry, and physics, as well as the personal and social implications of new technologies. This is consistent with a "whole learning" approach that relates learning to the life and culture of the individual.

A number of project leaders had been surprised to find that efforts targeted at one level of the educational system had unforeseen effects at a higher level. This "trickle-up" effect is caused by the elevated expectations of students who have been exposed to novel instruction and who then challenge higher-level teachers to update their instructional methods. Thus, the familiarity of graduating high school seniors with gene manipulation methods challenges college faculty to offer more entailed experiments with DNA in their introductory courses. Likewise, a growing number of middle school teachers who now allow their students to transform bacteria with a new gene challenge high school teachers to do even better experiments. This trickle-up effect is contrary to the traditional notion that educational innovation trickles down from higher levels. It suggests that focusing instructional change at the elementary level can have a multiplier effect, which, ultimately, ramifies throughout middle school, high school, and college. Furthermore, student and teacher enthusiasm, flexible scheduling, and lack of standardized curricula greatly simplify instructional change at the elementary level. Thus, with encouragement from the NSF, educators are now placing increased emphasis on upgrading elementary science instruction.

An undercurrent of tension, however, pervaded the meeting. Participants agreed that funding agencies' emphasis on *model* programs had created a patchwork of competing and often redundant programs, whose survival hangs on a nearly constant battle for grants. No foundation or agency, including NSF, has addressed the problem of how to provide continuing funding to mature programs whose usefulness as models has been established. Lacking long-term support, the very best investigators must devote inordinate effort to developing specific grant proposals and administering an intricate web of interlocking programs. Their rare communicative talents could be better employed writing new curricula, rather than writing still another grant.

The Need for Human Genome Education Centers

Many voices now argue that American biology education is in urgent need of major reform. The task of rebuilding the *biological education system* might be well served by strategies that have made America's *biological research system* without peer in the world. Mechanisms and infrastructures that support innovation in the biology laboratory might also support innovation in the biology classroom. NSF and other funders of biology education have, indeed, followed the lead of their research counterparts by providing most support to *individual investigators for well-defined projects of approximately 3 years duration.* However, well-supported, multidisciplinary research centers are another important element of biological research in the United States and include the Human Genome Research Centers funded by the National Institutes of Health (NIH) and the Department of Energy, NIH Comprehensive Cancer Centers and Program Project

Grants, and the Howard Hughes Medical Institutes. This approach acknowledges that innovation arises from a critical mass of highly motivated individuals. Such large-scale core support for exemplary centers is essentially absent from biology education today. (NSF and other federal agencies have provided major block grants to state education authorities, but these cannot be viewed as parallels to independent research centers.)

The educational challenges of the Human Genome Project present an ideal test for a centers approach in biology education. Imagine the potential impact of creating eight regional Human Genome Educational Centers—stable, well-equipped environments in which multidisciplinary teams of biologists, educators, designers, and computer programmers can devote their creative energies entirely to the problems of public genetics education. Genome Education Centers would be sited at innovative institutions with established educational outreach programs, expertise in genetics education, and strong linkages to research biology. If each center was funded for a renewable term of 5 years at a level of $500,000–750,000 per year, the total annual cost of the centers program would be less than 3% of the combined annual NIH-DOE budget for the Human Genome Project. The meeting at the University of Wisconsin made clear that the nucleus institutions for regional centers and an infrastructure for collaboration between them, in fact, already exists.

Plans for a Major Capital Development Program

A 1991 planning grant from the E.S. Webster Foundation allowed us to complete the concept design phase of a major capital development program, which would firmly establish the DNALC as a comprehensive prototype of such a Genome Education Center. An architectural study was conducted by Centerbrook Associates, who have been responsible for all of the major design work at the Laboratory for more than a decade. Floor plans and elevations of a 3500-square-foot *BioMedia* addition to the south of the building, redevelopment of the existing building, and a site plan for improved parking and visitor access were completed in time for the November meeting of the Board of Trustees.

The term *BioMedia* engenders our goal to explore ways to link together experimental, computer, and audiovisual resources to encourage understanding of biological concepts. The addition will include a genetics laboratory, multimedia computer laboratory, student research library, and a much needed atrium/lunchroom. The laboratory facilities will be adjacent to the existing *Bio2000* Laboratory and will include a redeveloped research/prep lab for instructional support and student research. The new and redeveloped facilities will allow students to move between biochemical experiments, microscope observations, and parallel computer experiences that illustrate molecular events. Library and laboratory resources will allow students to search the literature and work independently on specialized projects. Redevelopment of the original auditorium will create a 96-seat *Cellarium* for specialized video presentations and seminars. The new facility will also provide a much needed meeting space for the many small museums and educational organizations in the Cold Spring Harbor–Huntington area.

The capital campaign was quietly launched by year's end with lead grants of $250,000 from the Stone Foundation and $100,000 from the Weezie Foundation.

The Stone grant will outfit the *BioMedia* addition with specialized laboratory and computer equipment, including some items that we have for years only dreamed of affording. The laboratory equipment will be used for new student experiments in cell culture and microscopy and to support advanced research projects by student interns from neighboring school districts. The computer equipment will allow us to initiate a program of computer multimedia field trips to complement experiment field trips that are currently available. The Weezie grant will allow us to complete construction of a new permanent exhibit, *Exploring the Human Genome*, which will be located in a remodeled gallery in the existing building.

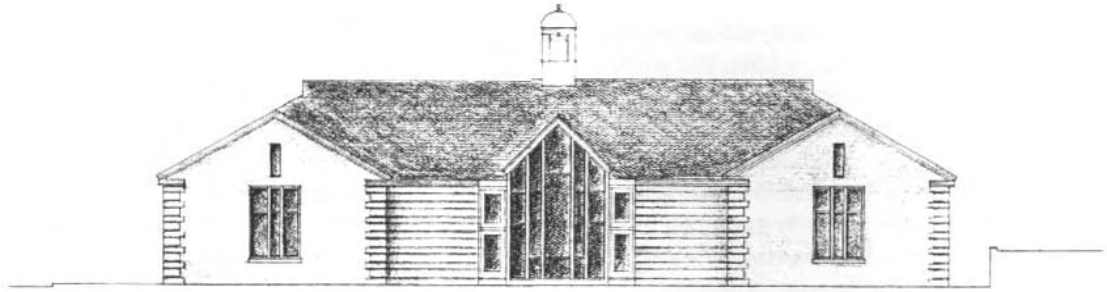
BioMedia Laboratory Development

With support from the New York State Legislature and the William Randolph Hearst Foundation, designer Susan Lauter has organized an efficient multimedia computing laboratory occupying the former offices on the main level. The *BioMedia* Laboratory is currently equipped with three Macintosh II computers, a top-of-the-line Quadra 900, and supporting audiovisual equipment. The Quadra will be the central file server of an integrated multimedia *network* of 12–15 computer stations, which will be installed in the student computer laboratory of the proposed *BioMedia* addition.

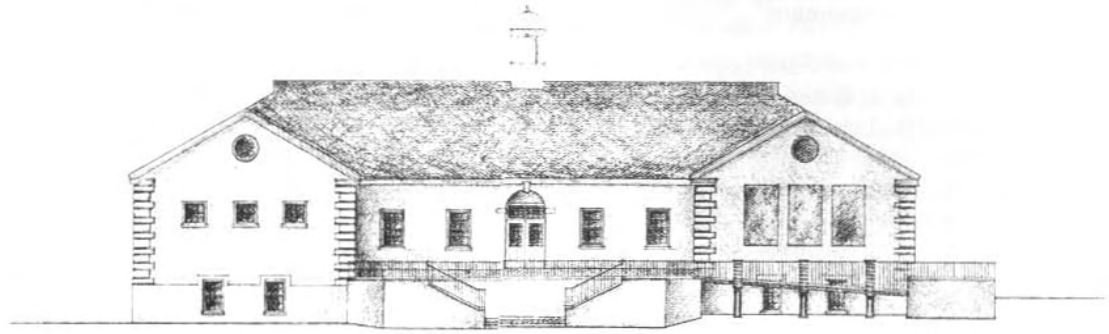
With strong support from our computer-savvy interns, Sue completed our first interactive computer program, *DNA Detective*, which features real-life cases involving DNA fingerprints. The program was presented to the museum world in October at the annual meeting of the Association of Science-Technology Centers in Louisville, Kentucky. *DNA Detective* is the first of eight multimedia computer programs scheduled for development as part of the forthcoming exhibit, *Exploring the Human Genome*.

Our ultimate objective is to configure the enlarged *BioMedia* Laboratory as a prototype node of a *BioMedia Network* to demonstrate the use of a central server to distribute multimedia programs to schools around the country. We intend to seek additional funding to purchase and maintain a multiprocessor and to install a fiber optic backbone and connections to public optical trunk lines. In this system, one central processor would respond to routine keyboard commands from clients' personal computers to retrieve files from the central storage disk; another processor is available to perform computationally intensive activities, such as manipulations of video files and three-dimensional rotations. Although a central multiprocessor is expensive, it would provide the computing power to allow simple receiving computers at client schools around the country to access and manipulate multimedia files maintained at the DNALC.

The *BioMedia* Laboratory also provides an unprecedented opportunity for students and biology educators to work coordinately with Cold Spring Harbor scientists as they develop a prototype computational system for genetic research. Cold Spring Harbor Laboratory is part of a newly formed consortium, funded by the External Research Program of Digital Equipment Corporation (DEC), which includes the California Institute of Technology, San Diego Supercomputer Center, University of Michigan, Massachusetts Institute of Technology, and Johns Hopkins University. The objective of the consortium is to develop "A Unified Interactive Environment for Scientific Collaboration" that will allow biologists to manage and interface effectively with the vast amounts of DNA and protein sequence data generated by human genome research. Laboratory staff scientist Thomas Marr, who helped conceive the DEC consortium, serves as *ad*



SOUTH ELEVATION



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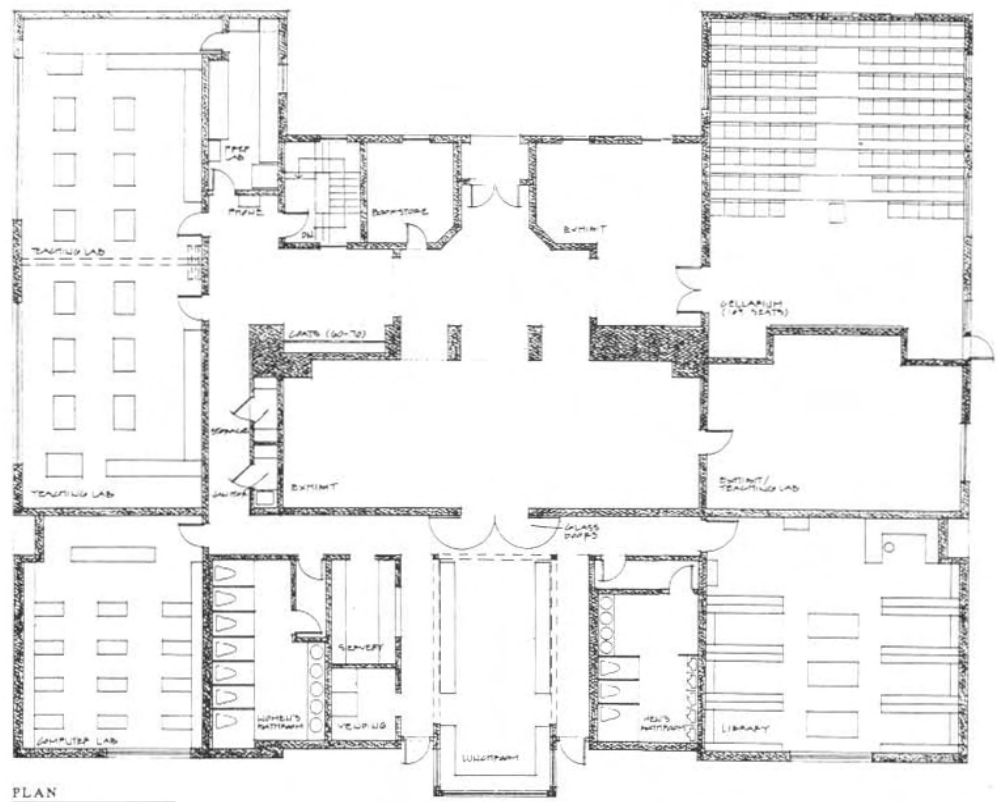
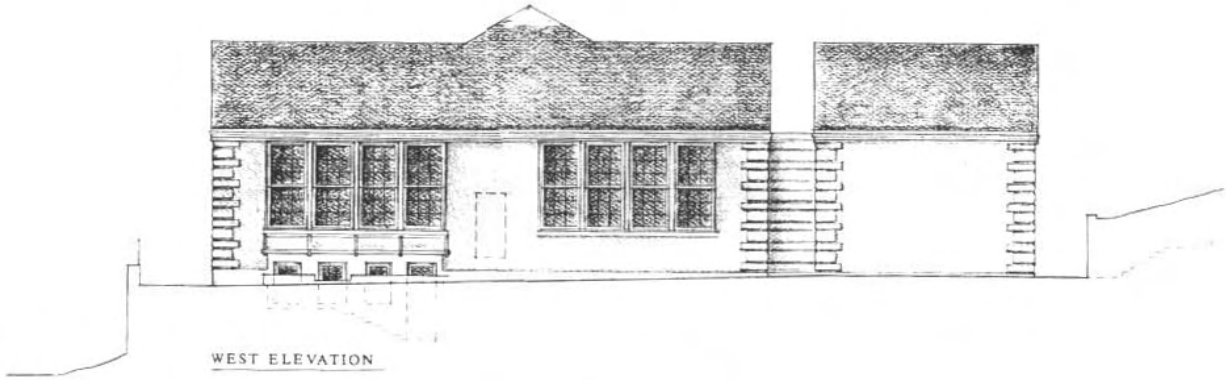


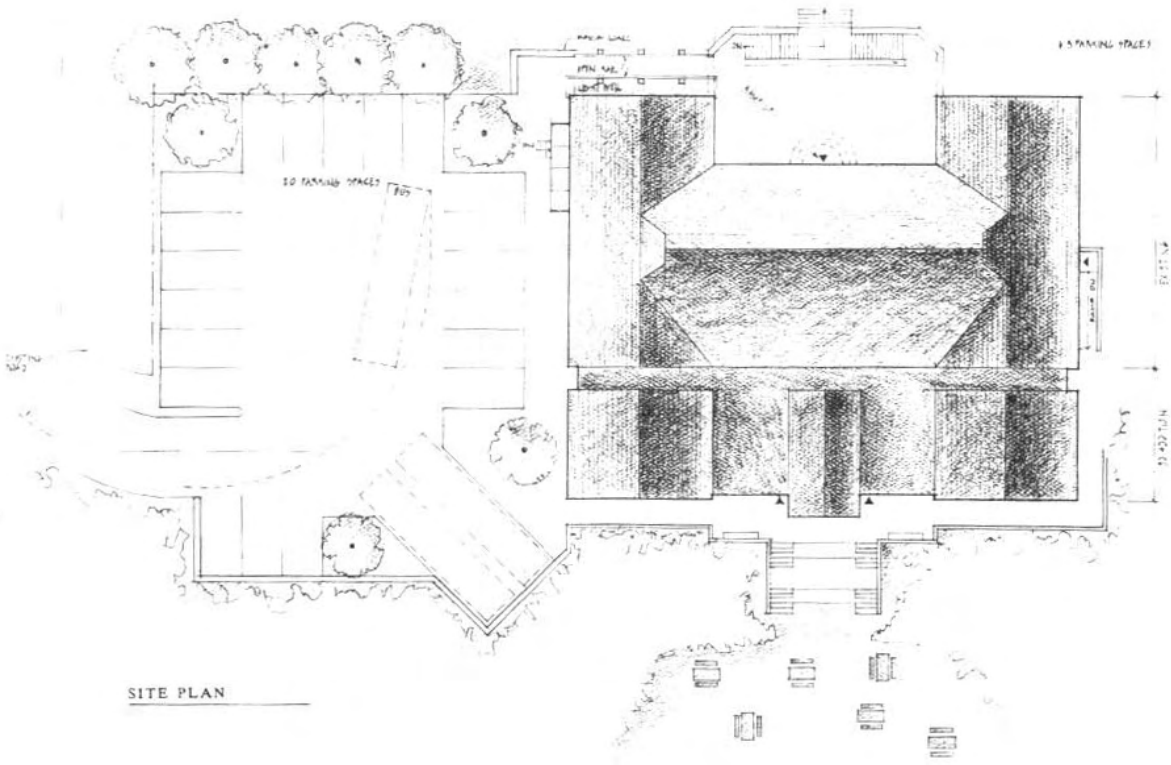
PLAN

Plans developed by Centerbrook Associates for the *BioMedia* addition to the DNA Learning Center.



WEST ELEVATION

EAST ELEVATION



SITE PLAN

hoc adviser to the *BioMedia* Laboratory. He can facilitate a direct flow of expertise, allowing us to apply solutions to problems of biological computing to educational computing:

- How to construct a "user friendly" computing network that allows information to be accessed at low cost by individuals in all parts of the country.
- How to allow transparent interfacing with different types of computers/operating systems (e.g., IBM vs. Mac).
- How to distribute computationally intensive activities among a number of regional "nodes."
- How to provide for real-time flow of computationally intensive activities between a central multiprocessor and personal computers.

Routinizing Human DNA Fingerprinting for Educational Purposes

In 1989, Mark Bloom began developing an experiment that would allow students to make their own DNA fingerprints using the automated procedure of polymerase chain reaction (PCR). We thought that this would be an ideal way to "personalize" gene technology and to illustrate the uses of individual DNA variations (polymorphisms) in forensic biology, identity testing, and disease diagnosis. In principle, the experiment is brilliantly safe and simple. Cheek cells are obtained by rinsing the mouth with a mild salt solution. The cells are collected by centrifugation, mixed with an agent to bind impurities, and boiled for several minutes to liberate DNA. A sample of this crude DNA extract is added to a "cocktail" of reagents that identifies and amplifies a specific region of DNA on chromosome 1. The amplified DNA is then separated by electrophoresis and stained with a dye that reveals a simple "bar code" consisting of one or two bands. However, routinizing the experiment so that it could be reproduced by novices proved daunting. The amplification procedure relies on pure biochemistry involving ten key components, each of which must be present in strictly prescribed amounts. Mark's experimental system worked brilliantly at first, but then crashed unexplainedly. In the course of more than 1 year of experiments, Mark tested and retested every component of the system, finally uncovering the culprit that had spoiled the results. In the process, he had become an authority on DNA amplification of this type.

Thanks to Mark's tenacity, the human DNA fingerprinting experiment has been successfully performed by members of diverse groups, including middle school through college faculty, business leaders, museum personnel, ethicians, and administrators from government agencies. At the end of the year, the experiment became part of the regular laboratory "menu" available for high school laboratory field trips. Comprehension of the experiment is much improved through an animated computer program, developed in our *BioMedia* Laboratory, that illustrates the complex biochemistry of the polymerase chain reaction. The program is available in a computer kiosk in the *Bio2000* Laboratory, which is linked to a new closed-circuit TV system. Thus, students can visualize the chemical reactions that are taking place in their test tubes. The DNALC is, to our knowledge, the only place in the world where DNA fingerprints are produced by nonscientists on a routine basis; we estimate that 1000–1500 students will perform this experiment annually.

Corporate Advisory Board Formed

Competition in the global market increasingly demands access to a number of emerging technologies. Gone are the days when a region could exist under a single government-supported industry. Most agree that the long-term economic health of Long Island depends on finding growth industry to replace an aged industrial infrastructure based on military aircraft. Many now look to biotechnology as a "great hope" for the Island's future. The preexisting infrastructure to support such an industry is often cited—a concentration of major research facilities with biotechnical expertise (Cold Spring Harbor Laboratory, Brookhaven National Laboratory, Cornell/North Shore Medical Center, and the new Picower Institute), a state-supported biotechnology center and industrial incubator at SUNY Stony Brook, and a number of existing start-up companies.

Less often considered is the educational infrastructure that primes technological development and community support. Since 1985, the DNALC of Cold Spring Harbor Laboratory has precipitated a quiet revolution within Long Island school systems. More than 300 faculty have been trained to bring cutting-edge biotechnology experiments into primary, secondary, and college classrooms. More than 4000 area students visit the DNALC each year to perform state-of-the-art experiments—many of which are not available to students elsewhere in the nation. Thanks to the partnership between DNALC staff and local educators, Long Island school systems rank alongside those of San Francisco as the nation's leaders in biotechnological education at the precollege level. The DNALC continues to build, at the grass-roots level, an educated constituency that supports the growth of high technology on Long Island. Moreover, it contributes to the academic excellence that can attract and retain the intellectual work force needed to drive Long Island's effort to retool itself for the gene age.

The biotechnology industry has acknowledged the DNALC as an innovative force in promoting biotechnological development. Biotechnology companies have supported its activities since 1986. A training program conducted by the DNALC was the kickoff event and continuing model for the education programs of the North Carolina Biotechnology Center, which is widely regarded for its effective promotion of the Research Triangle area. The Biotechnology Center at Stony Brook has supported the DNALC as its major contribution to public education and is now developing a "sister" learning center to serve teachers and students from eastern Suffolk County. Unfortunately, too few Long Islanders are aware of the DNALC and its role in the long-term economic health of the region. Thus, the Laboratory's Development Department was charged to work with us to establish a Corporate Advisory Board with the following objectives:

- To educate business leaders and the Long Island community about the importance of quality science education in maintaining Long Island's technological base, developing future talent, and attracting high-caliber employees.
- To identify opportunities for industry/DNALC partnerships to improve the quality of Long Island science and technology education.
- To provide expertise in strategic planning, marketing, and other business practices that will help ensure the DNALC's long-term success.
- To provide a sustainable level of annual core funding for DNALC programs from the Long Island business community—primarily to expand access to local students and teachers.

Corporate Advisory Board members brought high-level expertise and represented a range of businesses: Michael Aboff, President, Aboff's, Inc.; Mark Abrahams, President, Cybex; Thomas J. Calabrese, Vice President and General Manager-Long Island, New York Telephone; Vincent Carosella,President, Jetson Direct Mail Services; Marybeth Chritie, Community Affairs Manager, Cablevision; Robert E. Diller, Vice President-Marketing, Brinkmann Instruments; Douglas Fox, President, Newsday; D. Kent Gale, Chief Executive Officer, Daniel Gale Agency; Arthur D. Herman, Chairman, A.D. Herman Construction; Richard K. Koehn, Director, Center for Bio technology, SUNY, Stony Brook; Lilo Leeds, Chair, CMP Publications; Joseph McDonnell, Vice President, LILCO; Robert R. McMillan, McMillan, Rather, Bennett & Rigano, P.C.; Francis Roberts, Superintendent, Cold Spring Harbor Central School District; Paul A. Vermylen, Jr., Vice President-Finance, Meenan Oil Company, Inc.; Michael Vittorio, Vice President, Chase Manhattan Bank; and Lawrence Waldman, Partner, KMPG Peat Marwick.

Local Programs Expand Despite the Recession

It is a tribute to the foresightedness of school teachers and administrators that programs for local schools continued to flourish despite severe budget cutbacks. Membership in the Cold Spring Harbor Curriculum Study, for which there is an

Great Moments in DNA Science lecturers Lynda Sherlock, Scott Henderson, and Raymond O'Keefe.

annual fee, actually increased to 28 districts in 1991. Curriculum Study schools receive free or reduced admission to all DNALC programs, spaces in student/teacher workshops, and equipment purchase options. The *Bio2000* Laboratory operated at peak capacity, with 3900 students representing 75 high schools participating in hands-on experiments on DNA restriction analysis, bacterial transformation, and human DNA fingerprinting. The *Great Moments in DNA Science* series, which has been held annually since 1985, attracted 600 students and teachers to seminars on a range of topics:

- DNA Typing in Forensic Case Work, Lynda Sherlock, Suffolk County Crime Laboratory
- Clinical Applications of Human Gene Therapy, Elizabeth Fenjves, SUNY at Stony Brook
- 3-D Organization of the Cell Nucleus, Scott Henderson and Raymond O'Keefe, CSHL
- Telomerase and Aging, Carol Grieder, CSHL

A new grant from the William Randolph Hearst Foundation and continued support from the Center for Biotechnology at SUNY Stony Brook provided the impetus for us to greatly enlarge our enrichment activities for middle school students. Supported by these grants, Jane Conigliaro joined the staff in the spring and immediately organized a mailing to advertise a series of 5-day summer camps for gifted fourth to seventh graders. Calling on our network of teachers at collaborating schools on Long Island, we had hoped to fill four *Fun With DNA* Camps. Despite the late date and limited number of schools contacted, response was nearly overwhelming. Six *Fun With DNA* Camps were filled within several weeks of the announcement, drawing the participation of 150 students from 45 Long Island schools.

Fun With DNA focuses on science as a way of making sense of the world and solving problems. Students learn a system to expand creative and critical thinking skills while mastering basic principles of genetics and gene manipulation. Categorizing mutations in the fruit fly *Drosophila*, analyzing kernel characteristics in Indian corn, and compiling a ministudy of classmates' traits illustrate principles of variation and Mendelian genetics. Constructing models of biological structures ("baggie" cells and popsicle stick DNA) is paralleled by observing cells under the microscope and extracting DNA from bacterial cells. The relationship between genes and visible characteristics is discovered by adding a gene for antibiotic resistance to an antibiotic-sensitive strain of bacteria. In the culminating experiment, students construct a "DNA fingerprint" by cutting virus DNA with restriction enzymes and sorting the resulting fragments by size in an electric field. Current newspaper and magazine articles are used extensively to evaluate the use of DNA fingerprints in law and medicine, and as a basis for debate on societal issues of biotechnology. The highlight of each week was the final "parent participation day," when the student teams demonstrated experiments and explained to their parents what they had learned.

Following the great success of the the summer program, Jane organized a new program of laboratory field trips for middle school students. Modeled after the existing high school field trip program, *Genetic FUNdamentals* offers a "menu" of five genetics laboratories, each of which has been rigorously tested over a 2-year period during student and teacher workshops. Laboratories are of-

Fun With DNA participant, Stacey Mon, demonstrates a DNA extraction on Parent Participation Day.

fered Mondays and Fridays at the DNALC; special arrangements can be made for in-school instruction by DNALC staff. Teachers may select one laboratory as stand-alone enrichment or build a unit composed of several experiences. Participating teachers receive a planning packet to prepare students for the laboratory experience, including current articles, vocabulary list, pre- and post-activities, and topics for follow-up discussion. Fifty laboratories were booked for the 1991–92 school year, with an estimated 1000 students from 32 different schools participating. The new program increased student laboratory participation at the DNALC by 25%.

Minority and Special Programs

We always stand ready to assist graduates of our training courses in implementing DNA manipulation laboratories. However, we take special interest in collaborations to help upgrade biology teaching at minority institutions. This commitment dates to our earlier collaboration with the Josiah Macy, Jr., Foundation to set up molecular genetics laboratory programs at four minority high schools in the urban northeast—A. Phillip Randolph (Harlem), Clara Barton (Brooklyn), Dewitt Clinton (The Bronx), and Hill House School (New Haven)—and a Navajo Indian high school in Arizona. We also organized a mobile laboratory program to reach rural schools in Alabama. In 1991, we collaborated with Ventures in Education (the foundation spinoff of the Macy minority programs) to help set up a molecular genetics laboratory at the John McDonogh High School in New Orleans. We also collaborated with the Abell Foundation to set up model teaching laboratories at Baltimore City College High School and Baltimore Polytechnic Institute. In August 1991, Margaret Henderson traveled to Claverack State Prison to help instruct a laboratory illustrating principles of DNA fingerprinting to juvenile offenders. The program was arranged by Lynn Lee, a middle school teacher who participated in our NSF training program.

During the last several years, we have devoted a substantial portion of our NSF funds for teacher training in rural and historically minority regions of the south and southwest. For example, high school workshops have been held in Columbia and Charleston, South Carolina; Columbus, Mississippi; Murray, Kentucky; San Antonio, Texas; Pensacola, Florida; and Harvey, Louisiana. Additional workshops will serve rural populations in Kentucky, Arkansas, and the intermountain west in 1992. Morehouse College, in Atlanta, was the site of a college workshop in 1991 and Howard University will be a host school in 1992. NSF-sponsored workshops, at both the high school and college levels, will be held in Puerto Rico in 1992.

The DNALC's curriculum development and nationwide teacher training programs are funded through major federal and foundation grants; however, enrichment activities for local students are largely supported through fees charged to participating schools and/or parents. Although fees are waived in hardship cases, this funding dichotomy has limited participation by minority and disadvantaged populations in our own "back yard." Thus, late in 1991, we established a Special Programs Fund as a means to redress this situation.

Our experience thus far has highlighted the difficulties of introducing innovation in disadvantaged school settings—especially the need to overcome teachers' "science phobias" and to provide intensive support and follow-up. We will have to commit considerable staff resources if we are serious about providing enrichment opportunities to deserving schools in our local area. Therefore, the Special Programs Fund will initially be used to provide start-up support for minority *Fun With DNA* summer camps and an *Intensive Enrichment Program.* Through this program, we will essentially "adopt" several deserving school systems in the metro-New York area to demonstrate the vertical integration of the DNALC's existing laboratory curricula at several levels of instruction.

A Hectic Summer Schedule

Summer is traditionally reserved for teacher training workshops, and 1991 was our most rigorous to date. A hectic schedule of two college faculty workshops, eight high school faculty workshops, and 11 middle school faculty workshops was compounded by the addition of six *Fun With DNA* Camps for students. The organization of four different types of workshops in eight states is an extremely complicated task—mailing several thousand announcements; screening several hundred applications; shipping, setting up, and repacking approximately 500 pounds of reagents and equipment; motel reservations, paying participant stipends, etc. It still amazes us that (in a pinch) we can arrive at a location on Monday at 7:30 am, meet with our local organizer (often for the first time face-to-face!), unload a van-load of equipment, have a molecular biology laboratory functioning by 10:00 a.m. and still have time for a cup of coffee!

Developed in 1985 and supported by the NSF since 1987, the *DNA Science* Workshop is our best known workshop. The 5-day program, designed for advanced high school teachers, introduces modern methods for producing and analyzing recombinant DNA molecules, including microbial culture, gel electrophoresis, DNA restriction analysis, DNA ligation, and plasmid transformation and purification. In keeping with our recent geographical focus in the south and southwest, workshops were taught in Miami, Tampa, and Pensacola, Florida; Columbus, Mississippi; and Houston and San Antonio, Texas. These workshops—plus additional ones at the DNALC and in Montgomery County,

Maryland—drew 170 participants. Collaborators in California, Florida, and Wisconsin taught the *DNA Science* curriculum to 235 participants at ten additional workshops. Our records show that since 1985, the *DNA Science* curriculum has been the basis of at least 110 teacher-training workshops, organized by the DNALC and other education agencies, which have been taken by 2300 biology educators in 30 states.

The 4-day *Exploring Human Genetics* Workshop, developed under an NSF grant in 1990, prepares middle school instructors to introduce an experience-based unit on Mendelian and human genetics. The activities in this program are the basis of the *Fun With DNA* Camp and *Genetic FUNdamentals* field trips for middle school students. With strong support from Margaret Henderson, a cohort of New York State teachers trained in summer 1990 introduced new genetics activities during the 1990–1991 school year. Then, the lead teachers coordinated with Margaret to organize eight "second-round" workshops in summer 1991, which reached an additional 80 teachers in regions around the state. The lead teachers incorporated into the second-round workshop insights and resources drawn from their own classroom experiences during the prior school year. Several went on to share their experiences at professional conferences through-

Jane Conigliaro prepares middle school students to observe fruit flies with dissecting microscopes during a *Genetic Fundamentals* class.

out the state. A similar level of enthusiasm was evidenced by a second cohort of lead teachers trained in Maryland in summer 1991. Hopefully, the success of the New York and Maryland programs will demonstrate that this type of training can be replicated elsewhere in the nation.

Developed in 1989, the 10-day *Advanced DNA Science* Workshop introduces college faculty to many of the modern methods for analyzing complex genomes, including restriction mapping, gene library construction and screening, Southern hybridization, and polymerase chain reaction. The *Advanced DNA Science* curriculum articulates with and extends the concepts introduced in *DNA Science*. Structured to follow directly from an introduction to principles of biology, the entire laboratory series can form the basis of a first course in a molecular biology sequence, or appropriate sets of laboratories can be integrated as modules in many types of courses, including introductory biology, genetics, microbiology, and biochemistry. In summer 1991, 46 faculty from 24 states participated in NSF-sponsored *Advanced DNA Science* Workshops held at Morehouse College, Atlanta, and the University of California, San Francisco. As the San Francisco workshop was concluding, we were pleased to learn that the Fund for Improvement of Post-secondary Education, of the U.S. Department of Education, had approved a 2-year grant that will allow us to expand the college workshop program to four sites in summer 1992. After incorporating feedback from the summer 1992 workshops, the laboratories will be formally published later in the year as *Advanced DNA Science: An Introduction to Methods of Genome Analysis*.

College intern, Amy Phillips, prepares a colony hybridization; this lab is included in the new *Advanced DNA Science* curriculum.

New DOE Workshop for Opinion Leaders and Public Policy Makers

Communications and sociological research suggest that information campaigns have an indirect effect on public opinions and behavior. Information often flows to the public in two steps: "Opinion leaders" assess information from a variety of sources and form attitudes about issues. These well-informed individuals, in turn, influence the opinion and behaviors of people around them. Thus, information campaigns aimed at a relatively small number of opinion leaders may provide a cost-effective means to reach large segments of the general public.

With this model in mind, we collaborated with Jan Witkowski of the Laboratory's Banbury Center to design a new workshop for influential non-scientists who interface with human genetics research and society. We were very pleased when our program, *Human Genetic and Genome Analysis: A Practical Workshop for Opinion Leaders and Public Policy Makers*, received 2-year funding from the Department of Energy under its new program, Ethical, Legal, and Social Implications of the Human Genome Initiative. The first workshop was held in December, 1991 and drew together a heterogeneous mixture of congressional staff and government administrators, officers and staff in health-related foundations, genetic rights activists, science journalists, and staff at science museums.

The workshop is composed of three components that juxtapose the theory, practice, applications, and implications of human gene manipulation. Concept seminars, presented by Banbury and DNALC staff, introduce key principles that underpin human genome analysis, including Mendelian genetics, the molecular basis of inheritance, gene mapping and cloning, and DNA diagnosis. These topics were made tangible through laboratory sessions where participants construct a restriction map, transform *Escherichia coli* with an ampicillin resistance gene, and make their own DNA fingerprint using PCR. Feature seminars, presented by working scientists, provide first-person insight into the research process and the ethical dilemmas of human genetics research:

David Micklos (left foreground) monitors a bacterial transformation during "Human Genetics and Genome Analysis," a DOE-sponsored workshop for opinion leaders and public policy makers.

- Origins and Impacts of the Human Genome Project, David Galas, U.S. Department of Energy
- The Eugenics Movement, Philip Reilly, Shriver Center for Mental Retardation
- Cloning Human Disease Genes: Neurofibromatosis 1, Margaret Wallace, University of Florida Health Sciences Center
- The First Human Gene Therapy Trials, Ken Culver, National Institutes of Health
- Searching for Genes for Mental Disorders, Conrad Gilliam, Columbia University

International Collaborations: Ending the Cold War and "Warm Spring Harbor"

Following up on a collaboration initiated in 1990 with the Shemyakin Institute of Bioorganic Chemistry, Mark Bloom returned to Moscow in February to co-instruct a *DNA Science* Workshop with three Shemyakin staff members. The week-long workshop was attended by 12 students and 6 teachers selected for their science and English ability from four Moscow area high schools. Professor Konstantine Skryabin, Vice-Director of the Engelhardt Institute of Molecular Biology, opened the workshop with a seminar on the origins and implications of DNA manipulation technology. Participants used the *DNA Science* lab/text supplemented with Russian translations of the laboratory protocols, with Dr. Bloom and Dr. Nikolai Zvonok presenting laboratory briefings that alternated English with Russian translation. This team-teaching approach, coupled with meticulous preparation, yielded experimental results on par with those routinely achieved in the United States.

Efforts to continue the collaboration were delayed by the dramatic events that dissolved the former Soviet Union. As the year ended, we received word from

Professor V.T. Ivanov, Director of the Shemyakin Institute, that funds to continue our exchange were available through the newly formed Russian Academy of Sciences. With this letter of support in hand, we submitted a request to NSF for a 3-year Russian/American program in Undergraduate Biomolecular Manipulation.

The year also brought opportunity for a new collaboration with Marcello Siniscalco. A human geneticist of the first order, Marcello has based his life's research on the island of Sardinia, where his early studies provided evidence that the gene for the blood disorder thalassemia provides protection from malignant malaria. In the 1950s, he showed that thalassemia was restricted primarily to populations living in lowland areas of Sardinia, where malaria had been prevalent. Our friendship with Marcello dates to 1985, when, on sabbatical at Cold Spring Harbor Laboratory, he and his family lived next door to Dave Micklos. Over the years, Marcello had watched with keen interest the development of the DNA Learning Center.

Several years ago, Marcello left his research position at Memorial Sloan Kettering Cancer Center to assume responsibility for the development of a new genetics research institute on the Sardinian coast—the Porto Conte Research and Training Laboratories, which will open in 1992. Marcello's intent is to model his new institution after Cold Spring Harbor Laboratory, and, due to its location on the warm waters of the Mediterranean Sea, he refers to the Porto Conte facility as "Warm Spring Harbor." He envisioned public genetics education as an integral part of the new institute and set about to gather support for a museum of science modeled after the DNA Learning Center.

Marcello invited Dave to Sardinia to participate in a week of "Disseminating Scientific Culture," March 18–22, sponsored by the Italian Ministry of Scientific and Technological Research. Although events were held at universities and science museums throughout the country, the Sardinian event was the largest and most publicized in Italy. Participants included Nobel laureate Rita Levi Montalcini and Piero Angela, a television science reporter whose phenomenal celebrity is comparable to Walter Cronkite in his heyday. The need for DNA literacy took on national scope during a 50-minute program on Italian network television, moderated by Piero Angela and Marcello Siniscalco, which included a 15-minute documentary on the DNA Learning Center.

The proposed collaboration gained substance in December, when Marcello received a major grant from the Italian Ministry of University, Scientific and Technological Research, to develop plans for a science museum at Porto Conte. Marcello, in turn, subcontracted the DNALC to produce a mini-exhibit to be displayed in Sassari, Sardinia as a focal point of celebrations conducted there during the Italian national "Week of Science," in April. The "genetic video arcade" will include four interactive computer modules, which will play several multimedia programs developed with Hearst support–*DNA Detective*, *DNA Diagnosis*, and *Gene Therapy*. Following presentation during the Italian Week of Science, the video arcade will be installed at the Porto Conte Research and Training Laboratories in anticipation of its own museum. Marcello's efforts, together with the Italian translation of *DNA Science* by the Piccin New Library, will likely establish Italy as a European model for public genetics education.

Staff and Interns

In early spring, we recruited a new part-time staff member, Jane Conigliaro, to take responsibility for expanding our programs for middle school students. With

degrees in elementary and special education, Jane has consulted for six Long Island school districts to design multidisciplinary programs for intellectually gifted elementary and middle school students. In addition to her position here, Jane juggles a consultancy for Roslyn Public Schools, an adjunct faculty position at Long Island University's C.W. Post campus, and a private practice in the remediation of learning disabilities. Jane was among the first local educators to use the DNALC as an enrichment opportunity for young students. She also served on the advisory committee for the original *Fun With DNA* student workshop in 1988 and the NSF training program for middle school teachers. Her interest in educating the "whole child" and unique ability to facilitate associative learning is an inspiration to the staff, as well as to the many teachers for which she is a model educator.

A number of middle and high school faculty assisted with summer programs, getting a "micro-teaching" experience and a behind the scenes look at how our workshops run. *DNA Science* Workshop alumnus Ellen Mayo, of Douglas Freeman High School in Richmond, traveled with us to instruct workshops in Miami and Tampa. A number of faculty assisted with instruction of the *Fun With DNA* Camps: Barbara Cullen, Huntington SEARCH Gifted Program; Gerri Faivre, East Woods School; Peggy Frisina; Karen Gough, Half Hollow Hills High School; Diane Jedlicka, Roslyn OMNI Gifted Program; James Lauter, Huntington Elementary School; Adele Nicefero, Hicksville Academic Enrichment Program; and Nancy Van Vranken, St. Bernard's School.

A small group of high school interns supply "behind the scenes" support that allow us to provide high-quality laboratory experiences to more than 4000 precollege students per year. Before departing for her first year at SUNY, Geneseo, senior intern Amy Phillips pretested experiments for the *Advanced DNA Science* curriculum. She became so proficient with these advanced techniques that she functioned as sole laboratory aide for two 10-day summer workshops for college faculty—a task previously performed by undergraduate and graduate interns. Mark Staudinger, a junior at Cold Spring Harbor High School, functioned without flaw as laboratory aide at *DNA Science* Workshops held in Houston, San Antonio, and the DNALC. Nicole Nicefero, a senior at Cold Spring Harbor High School, functioned as a mentor to younger students participating in five *Fun With DNA* Workshops. New interns Maggie Choi, a sophomore at Syosset High School and Charles Rexer, a senior at Manhasset High School, assumed responsibility for the *Bio2000* Laboratory, but also found time for independent research projects.

With the opening of the *BioMedia* Laboratory, interns also have the opportunity to apply their computer abilities to the problems of biology education. Intern involvement in multimedia development began during a summer stay by Claudio Siniscalco, the son of our Italian collaborator, Marcello. A freshman at Westminster School in London, Claudio completed casework for the initial program, *DNA Detective*. David Hollman, a junior at Cold Spring Harbor High School, completed a program that accesses a laser disk containing video demonstrations of student laboratory techniques. The program is now used in the *Bio2000* Laboratory, allowing our instructors to call up, at the touch of a button, appropriate video clips that serve as visual references to assist students as they perform experiments.

Publication

Bloom, M., G. Freyer, and D. Micklos. *Advanced DNA Science An Introduction to Methods of Genome Analysis*. (In preparation.)

Sites of Major 4–8 Day Workshops 1985–1991

ALABAMA	University of Alabama, Tuscaloosa	1987,1988,1989,1990
ARIZONA	Tuba City High School	1988
CALIFORNIA	University of California, Davis	1986
	San Francisco State, San Francisco	1991
CONNECTICUT	Choate Rosemary Hall, Wallingford	1987
FLORIDA	N. Miami Beach Senior High School, Miami	1991
	University of W. 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, Chicago	1986, 1987
INDIANA	Butler University, Indianapolis	1987
IOWA	Drake University, Des Moines	1987
KENTUCKY	Murray State University	1988
LOUISIANA	Jefferson Parish Public Schools, Harvey	1990
MANITOBA	Red River Community College, Winnipeg	1989
MARYLAND	Annapolis Senior High School	1989
	McDonogh School, Baltimore	1988
	Montgomery County Public Schools	1990,1991
	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
MICHIGAN	Athens High School, Troy	1989
MISSISSIPPI	Mississippi School for Math & Science, Columbus	1990,1991
MISSOURI	Washington University, St. Louis	1989
NEW HAMPSHIRE	St. Paul's School, Concord	1986,1987
NEW YORK	Albany High School	1987
	Bronx High School of Science	1987
	Cold Spring Harbor High School	1985,1987
	DeWitt Middle School, Ithaca	1991
	DNA Learning Center, High School Workshop	1988(3),1989(2), 1990(2), 1991
	DNA Learning Center, College Workshop	1990
	DNA Learning Center, Middle School Workshop	1990,1991
	Fostertown School, Newburgh	1991
	Huntington High School	1986
	Irvington High School	1986
	Junior High School 263, Brooklyn	1991
	Lindenhurst Junior High School	1991
	Orchard Park School, Orchard Park	1991
	Plainview-Old Bethpage Middle School, Plainview	1991
	State University at Purchase	1989
	State University at Stony Brook	1987,1988,1989,1990
	Titusville Middle School, Poughkeepsie	1991
	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, Westerville	1990
PENNSYLVANIA	Duquesne University, Pittsburgh	1988
	Germantown Academy, Fort Washington	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
VERMONT	University of Vermont, Burlington	1989
VIRGINIA	Jefferson School of Science, Alexandria	1987
	Mathematics and Science Center, Richmond	1990
WEST VIRGINIA	Bethany College	1989
WISCONSIN	Marquette University, Milwaukee	1986,1987
	University of Wisconsin, Madison	1988,1989
WYOMING	University of Wyoming, Laramie	1991

1991 Workshops, Meetings, and Collaborations

January 10	Meeting, Association of American Colleges, Washington, D.C.
January 25	Congressional Workshop, DNA Learning Center, Cold Spring Harbor, New York
January 25–26	Follow-up High School Workshop, National Science Foundation, Kamehameha Secondary School, Honolulu, Hawaii
January 29–Feb. 11	High School Workshop, Shemyakin Institute, Moscow, Russia
February 2–3	Follow-up High School Workshop, National Science Foundation, Jefferson Parish Public Schools, Harvey, Louisiana
February 26	Seminar, University of Massachusetts, Amherst, Massachusetts
March 2	Middle School Follow-up Workshop, National Science Foundation, Albany, New York
March 8–10	Meeting, Math and Science Schools, Columbus, Mississippi
March 14	Great Moments in DNA Science, Curriculum Study, Cold Spring Harbor, New York
March 18–22	Italian Week at Science, Sassari, Sardinia
March 26–31	NSTA Meeting, Houston, Texas
April 4	Great Moments in DNA Science, Curriculum Study, Cold Spring Harbor, New York
April 11	Great Moments in DNA Science, Curriculum Study, Cold Spring Harbor, New York
April 11–13	College Workshop, Bates College, Lewiston, Maine
April 15–17	Collaboration with Terri Woodin of University of Nevada, Reno
April 17	Great Moments in DNA Science, Curriculum Study, Cold Spring Harbor, New York
April 22	Abell Foundation Meeting, Baltimore, Maryland
June 3–4	Collaboration with Raynard Sanders and Michelle Brierre of New Orleans, Louisiana
June 10–14	High School Workshop, National Science Foundation, University of West Pensacola, Florida
June 12–14	ABLE Workshop, Laramie, Wyoming
June 17–21	High School Workshop, National Science Foundation, Armwood Senior High School, Tampa, Florida
June 24–26	Second-round Middle School Workshop, National Science Foundation, Lindenhurst, New York
June 24–28	High School Workshop, National Science Foundation, N. Miami Beach Senior High Schools, Miami, Florida
	High School Workshop, National Science Foundation, Mississippi School for Math and Sciences, Columbus, Mississippi
June 25–27	Second-round Middle School Workshop, National Science Foundation, Poughkeepsie, New York
June 27–July 1	Second-round Middle School Workshop, National Science Foundation, DNA Learning Center, Cold Spring Harbor, New York
July 8–10	Second-round Middle School Workshop, National Science Foundation, Ithaca, New York
July 8–12	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 8–19	College Workshop, National Science Foundation, Morehouse College, Atlanta, Georgia
July 10–12	Second-round Middle School Workshop, National Science Foundation, Orchard Park, New York
July 15–19	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 22–26	High School Workshop, Montgomery County, Burtonsville, Maryland
	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 29–August 1	Middle School Workshop, National Science Foundation, Annapolis, Maryland
July 29–August 2	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York

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February 26	Seminar, University of Massachusetts, Amherst, Massachusetts
March 2	Middle School Follow-up Workshop, National Science Foundation, Albany, New York
March 8–10	Meeting, Math and Science Schools, Columbus, Mississippi
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June 17–21	High School Workshop, National Science Foundation, Armwood Senior High School, Tampa, Florida
June 24–26	Second-round Middle School Workshop, National Science Foundation, Lindenhurst, New York
June 24–28	High School Workshop, National Science Foundation, N. Miami Beach Senior High Schools, Miami, Florida
	High School Workshop, National Science Foundation, Mississippi School for Math and Sciences, Columbus, Mississippi
June 25–27	Second-round Middle School Workshop, National Science Foundation, Poughkeepsie, New York
June 27–July 1	Second-round Middle School Workshop, National Science Foundation, DNA Learning Center, Cold Spring Harbor, New York
July 8–10	Second-round Middle School Workshop, National Science Foundation, Ithaca, New York
July 8–12	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 8–19	College Workshop, National Science Foundation, Morehouse College, Atlanta, Georgia
July 10–12	Second-round Middle School Workshop, National Science Foundation, Orchard Park, New York
July 15–19	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 22–26	High School Workshop, Montgomery County, Burtonsville, Maryland
	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
July 29–August 1	Middle School Workshop, National Science Foundation, Annapolis, Maryland
July 29–August 2	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York

August 5–9	Workshop, National Science Foundation, Taft High School, San Antonio, Texas
	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
August 5–16	College Workshop, National Science Foundation, University of California, San Francisco, California
August 12–14	Second-round Middle School Workshop, National Science Foundation, Delmar, New York
August 12–16	High School Workshop, National Science Foundation, Langham Creek High School, Houston, Texas
	Fun With DNA, DNA Learning Center, Cold Spring Harbor, New York
August 14–16	Second-round Middle School Workshop, National Science Foundation, Newburgh, New York
August 26–28	Second-round Middle School Workshop, National Science Foundation, Germantown, New York
August 26–30	High School Workshop, Curriculum Study, DNA Learning Center, Cold Spring Harbor, New York
August 27–29	Second-round Middle School Workshop, Brooklyn, New York
August 28–30	Second-round Middle School Workshop, Plainview, New York
September 19	Physicians' Continuing Education Program, Huntington Hospital, Huntington, New York
September 23–24	Carolina Biological Supply Co., Burlington, North Carolina
October 1	New Jersey Science Workshop
October 8–9	Project Share, Middle School Workshop, Killingworth, Connecticut
October 18–21	ASTC, Louisville, Kentucky
October 23	Rutgers University Lecture, New Jersey
October 26–27	Follow-up High School Workshop, National Science Foundation, University of West Florida, Pensacola, Florida
October 28–30	Meeting, Madison, Wisconsin
November 1	NRC Meeting, Washington, D.C.
November 2–3	DOE Grant Meeting, Washington, D.C.
November 3–23	WHO Grantee, Antonio Jacalne, Manila, Phillippines
November 5–6	Middle School Workshop, Centerbrook, Connecticut
November 9–10	Follow-up High School Workshop, National Science Foundation, Langham Creek High School, Houston, Texas
November 14	Genome Presentation, Baltimore, Maryland
November I5	Lecture, United States Military Academy, West Point, New York
November 15	Site Visit, Raynard Sanders of New Orleans, Louisiana
November 15–16	Follow-up High School Workshop, Montgomery County, Maryland
December 7–8	Follow-up High School Workshop, National Science Foundation, Mississippi School for Math and Science, Columbus, Mississippi
December 8–11	DOE Workshop, Cold Spring Harbor, New York
December 9–11	Proposal Development Workshop, Washington, D.C.
December 14–15	Follow-up High School Workshop, National Science Foundation, Taft High School, San Antonio, Texas

DNA LEARNING CENTER GRANTS

Grantor	*Program/Principal Investigator*	*Duration of Grant*	*Total Award*
FEDERAL GRANTS			
NATIONAL SCIENCE FOUNDATION			
	High School Faculty Enhancement	1990–1993	474,036
	Middle School Faculty Enhancement	1990–1993	252,614
	College Faculty Enhancement	1991–1993	264,467 *
DEPARTMENT OF EDUCATION			
	College Faculty Enhancement	1991–1993	177,925 *
DEPARTMENT OF ENERGY			
	Opinion Leader Workshops (joint grant with Banbury Center)	1991–1993	128,059 *
NONFEDERAL GRANTS			
Brinkmann Instruments, Inc.	Special Programs	1991	2,000 *
CMP Foundation	Special Programs	1991	1,000 *
Corporate Advisory Board	Special Programs	1991	14,500 *
CSHL Centennial Fund	"Partners in the Future"	10/91–6/92	27,000 *
Harweb Foundation	Special Programs	1991	2,000 *
William Randolph Hearst Foundation	Middle School Program	1991–1992	35,000 *
Howard Hughes Medical Institute Montgomery County, Maryland	High School Faculty Enhancement	1990–1993	46,500
The Esther A. and Joseph Klingenstein Fund, Inc.	Core Support	1989–1991	75,000
Josiah Macy, Jr. Foundation	Core Support	1990–1991	98,905
Richard Lounsberry Foundation	Core Support	1991	35,000 *
Natural Heritage Trust, New York State	Exhibit Support	1991	66,300 *
Stone Foundation	Capital Support	1991–1994	250,000 *
Nancy Van Vranken	Core Support	1991	500 *
Edwin S. Webster Foundation	Capital Support	1991	15,000 *
The Weezie Foundation	Exhibit Support	1991–1992	100,000 *
John R. Young	Special Programs	1991	5,000 *
Hillsborough County, Tampa, Florida	Vector Workshop	1991	2,410 *
Independent School Districts, Houston	Vector Workshop	1991	2,400 *
Mississippi School for Math and Science	Vector Workshop	1991	7,300 *
Northside Independent School District, San Antonio	Vector Workshop	1991	2,410 *
Project Share, Killingworth, Connecticut	Vector Workshop	1991	1,900 *
SUNY at Stony Brook	Middle School Program	1991	10,000 *
Commack Union Free School District	Curriculum Study	1991	500
East Williston Union Free School District	Curriculum Study	1991	500
Garden City Union Free School District	Curriculum Study	1991	1,500
Great Neck Public Schools	Curriculum Study	1991	500

* New Grants Awarded in 1991

Grantor	*Program/Principal Investigator*	*Duration of Grant*	*Total Award*
Half Hollow Hills Central School District	Curriculum Study	1991	500
Harborfields Central School District	Curriculum Study	1991	500
Herricks Union Free School District	Curriculum Study	1991	500
Huntington Union Free School District	Curriculum Study	1991	500
Island Trees Union Free School District	Curriculum Study	1991	500
Jericho Union Free School District	Curriculum Study	1991	500
Kings Park Central School District	Curriculum Study	1991	1,500
Lawrence Union Free School District	Curriculum Study	1991	500
Lindenhurst Union Free School District	Curriculum Study	1991	500
Locust Valley Central School District	Curriculum Study	1991	500
Manhasset Union Free School District	Curriculum Study	1991	500
Massapequa Union Free School District	Curriculum Study	1991	2,000*
Northport-East Northport Union Free School District	Curriculum Study	1991	500
North Shore Central School District	Curriculum Study	1991	500
Oyster Bay-East Norwich Central School District	Curriculum Study	1991	500
Plainview-Old Bethpage Central School District	Curriculum Study	1991	500
Plainedge Union Free School District	Curriculum Study	1991	500
Portledge School	Curriculum Study	1991	500
Port Washington Union Free School District	Curriculum Study	1991	500
Roslyn Public Schools	Curriculum Study	1991	500
Sachem Central School District at Holbrook	Curriculum Study	1991	500
South Huntington Union Free School District	Curriculum Study	1991	500
Syosset Central School District	Curriculum Study	1991	500

* New Grants Awarded in 1991