ChE at City College of New York

REUEL SHINNAR
City College of New York • New York, NY

City College was founded in 1847 as the Free Academy, the first public college in the United States, 15 years before passage of the Morrill Act establishing the land-grant colleges, and before widespread acceptance of the principle of public higher education. A college "where the children of laborers and gentlemen could study together" was the dream of New York patrician Townsend Harris, but Harris had to agree, in the face of opposition from Columbia College, that the Free Academy would not offer degrees in fields that are "the sole domain of gentlemen," such as medicine, law, and theology. The college currently occupies a 35-acre, gargoyle-lined, Gothic and modern campus in the historic Hamilton Heights section of upper Manhattan, near the home of Alexander Hamilton.

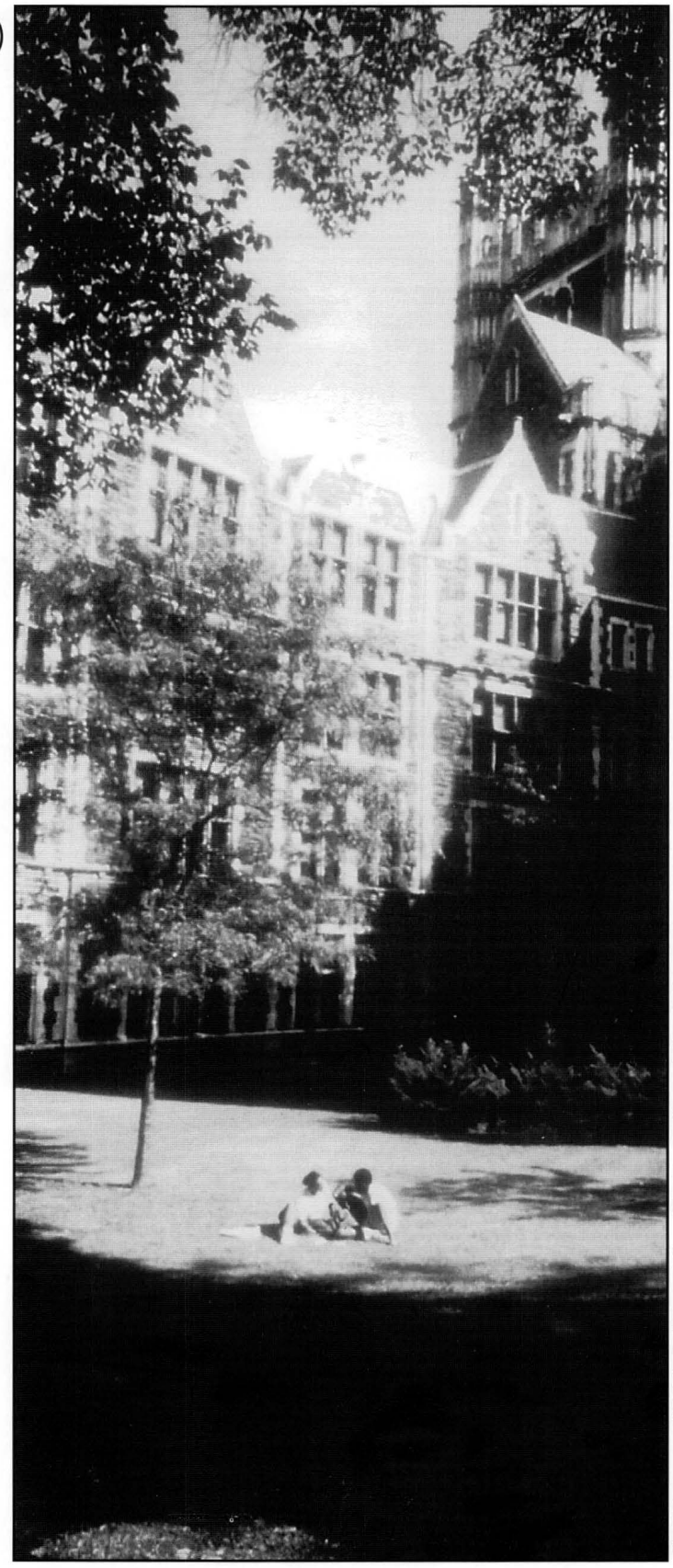

Photo Courtesy of Public Relations Office, The City College of New York, CUNY

The bucolic City College campus contrasts with bustling New York City.

Admission was based solely on merit, and the College of the City of New York (as it was renamed in 1866), or CCNY, charged no tuition until 1976. It therefore served as the vehicle for higher education for New York's immigrant communities, and the college was able to attract an outstanding student body, giving rise to the name "the Harvard of the proletariat." When opportunities for graduate education and research began to develop in the United States in the 20th century, the graduates of City College found open doors. City College has graduated eight Nobel laureates, more than any other public-domain academic institution in the United States. Many members of the National Academies of Engineering and Sciences and the Institute of Medicine are its graduates. The college ranks fourth in the United States in the total number of graduates in all disciplines who have gone on to earn the PhD, and it ranks first in chemistry, economics, and psychology. It ranks eighth in producing top-level executives in American business and industry.

City College always offered programs in technology and had a professor of civil engineering from the earliest times. George Goethals, the builder of the Panama Canal, was a student at CCNY for three years before transferring to the Military Academy at West Point, and the renowned bridge designer, David Steinman, was a City College graduate.

A separate School of Engineering was established in 1917, and the first class in chemical engineering graduated in 1921. The class of 1926 included a woman, one of the first to enter the profession. The college had a standard chemical engineering curriculum through the 1950s. There was no research or graduate education, but many faculty members had industrial experience and did industrial consulting. Perhaps the best known was Morris Kolodney, who played a significant role as a metallurgist in the Manhattan Project. Many graduates went on to obtain the PhD and to become leaders in the profession. The graduates of this period include National Academy of Engineering members George Newhauser (1958), Institute Professor at Georgia Tech; Arnold Stancell (1958), formerly a Mobil vice-president and now a Georgia Tech professor; Andrew Grove (1960), the co-founder of Intel; Martin Sherwin (1960), a former W.R. Grace corporate vice-president; Stanley Sandler (1962), the H.B. duPont Professor at the University of Delaware; and Frederick Krambeck (1963), a senior consultant at ExxonMobil.

Three more colleges were established in the 1920s to meet the growing educational needs of the City of New York, including Hunter College for women. (At the time, only the School of Engineering accepted women.) These four colleges, all of which subsequently became coeducational, later formed the nucleus of the present City University of New York (CUNY), which is the third largest university in the United States and the largest urban university. Graduate education was introduced in CUNY in the early 1960s, and PhD programs in engineering were established at City College. Two chemical engineering graduates, Martin Sherwin (the first to receive a PhD in chemical engineering from the college) and Frederick Krambeck are members of the National Academy of Engineering.

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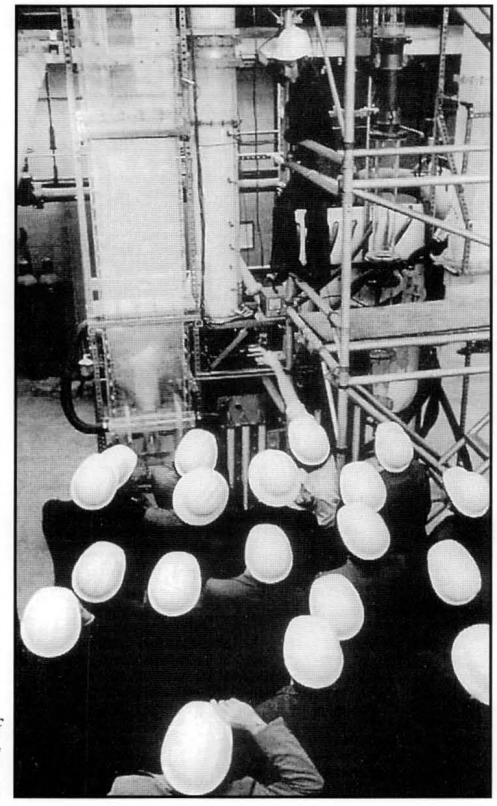
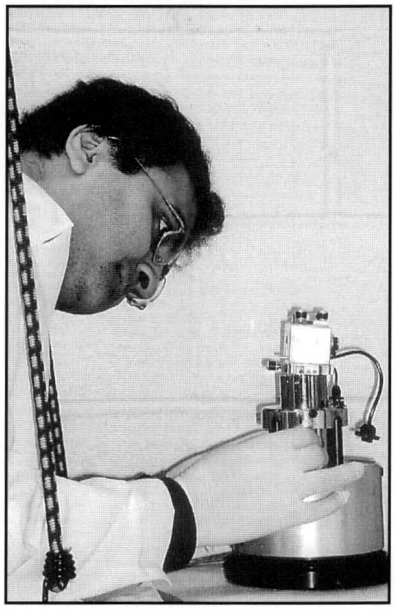
In 1962, the School of Engineering moved into a new building which met the needs of research-oriented graduate programs. The chairman of the Chemical Engineering Department at the time was Alois X. Schmidt. While not a researcher himself, Schmidt was an excellent and insightful manager who spearheaded the introduction of modern chemical engineering into the curriculum. He hired two young faculty members who would grow with the department, Robert Pfeffer, later department chair for 15 years and subsequently provost of City College, and Robert Graff, the current chair. Together with Seymour Hyman (a chemical engineering professor who was serving as the new graduate dean for engineering who would later become the vice chancellor of the university), Schmidt sought out established chemical engineers who could help develop a graduate program and provide guidance for the young faculty members.

The first senior faculty member Schmidt recruited was Stanley Katz, then at American Cyanamid. Katz was a mathematician by training who worked for 15 years in the chemical industry and had written seminal papers on such chemical engineering topics as polymerization kinetics and the optimal design and operation of staged systems. He, in turn, initiated the hiring of Reuel Shinnar, and together they es-

◄ PhD student working inside a Class 100 clean room to identify crystals prepared by a newly developed templating technique.





◄ Doctoral student Nitin Kumar prepares atomic force microscope for observations of the molecular surface topology of a silicon wafer modified by a molecular self-assembly technique.

► Demonstration for industry of the CCNY circulating fluid bed test facility.

tablished a pioneering research program using applied probability and Markov processes to solve problems in chemical engineering. The use of population balances to model crystallizers, coalescence processes, molecular weight distributions, multiple tracer experiments, etc., was developed and formulated in this group.

The group also worked on problems of stability of flow of polymeric liquids. A 1969 paper by Pfeffer, Shinnar, and their students, Goldin and Yerushalmi, showed that the tensile stresses developed by the presence of small amounts of polymer can prevent a jet from breaking up under the effect of surface tension. A photograph from this classic work, which anticipates issues in modern technologies such as jet printing, was shown as recently as a year ago during a plenary lecture by Gareth McKinley at the International Congress on Rheology.

Katz died prematurely in 1971. His profound impact on chemical engineering at City College is recalled annually through the Stanley Katz Memorial Lecture, which is presented by a leader of the chemical engineering profession. Shinnar subsequently moved his research emphasis from applied probability to the development of rigorous methods for the design and control of chemical processes, especially chemical reactors. He also pioneered a new methodology for the economic evaluation of new processes that has been widely accepted in industry. In 1985, Shinnar was elected to the National Academy of Engineering, becoming the first member of the department and the school to receive this honor. The process-analysis component was augmented when Irven Rinard joined the faculty in 1988. Rinard, a former associate of Katz, had been in charge of reaction engineering and control at the Scientific Design Company for more than 20 years. He continues to collaborate with Shinnar in design and control research and has started an activity in microreactor processes.

The department recruited Arthur Squires in the late 1960s to strengthen the traditional engineering aspects of the program. Squires was a physical chemist who played a significant role in the isotope separation

TABLE 1

Faculty: CCNY's Department of Chemical Engineering

(Additional information can be found on the web page at www.che.engr.ccny.cuny.edu)

Andreas Acrivos (PhD, University of Minnesota, 1954)
- Rheology of concentrated suspensions
- Dielectrophoresis in flowing suspensions
- Dynamical systems theory and chaotic particle motions

Alexander Couzis (PhD, University of Michigan, 1992)
- Polymorph selective templated crystallization
- Molecularly thin organic barrier layers
- Surfactant facilitated wetting of hydrophobic surfaces

Morton M. Denn (PhD, University of Minnesota, 1964)
- Non-Newtonian fluid mechanics
- Polymer processing and rheology
- Polymer interfaces

M. Lane Gilchrist (PhD, University of California, Davis, 1996)
- Bioengineering with cellular materials
- Spectroscopy-guided molecular engineering
- Structural studies of self-assembling proteins

Robert A. Graff (D Eng Sc, Columbia University, 1963)
- Pollution prevention
- Remediation

Leslie L. Isaacs (PhD, Massachusetts Inst. of Tech., 1960)
- Preparation and characterization of novel optical materials
- Recycling of pavement materials
- Application of thermo-analytic techniques in materials research

Charles Maldarelli (D Eng Sc, Columbia University, 1980)
- Surfactant science and interfacial transport phenomena
- Fluid mechanics and hydrodynamic stability
- Nano science and engineering

Irven Rinard (Sc D, Massachusetts Inst. of Tech., 1962)
- Process design methodology
- Dynamic process simulation and process control
- Microreaction technology

David Rumschitzki (PhD, U. of California, Berkeley, 1984)
- Reaction engineering
- Transport and reaction aspects of artery disease
- Hydrodynamics of two-phase flow in tubes

Reuel Shinnar (D Eng Sc, Columbia University, 1957)
- Advanced methods for chemical process design and control
- Spinodal decomposition of binary solvent mixtures
- Process economics
- Systems problems in energy and the environment

Carol A. Steiner (PhD, University of Pennsylvania, 1983)
- Polymeric hydrogels
- Polymer/surfactant interactions
- Controlled drug release

Gabriel Tardos (D Sc, Technion, Israel, 1978)
- Powder technology
- Granulation of powders
- Granular flows

Herbert Weinstein (PhD, Case Institute of Technology, 1963)
- Fluidization and multiphase flows
- Multiphase chemical reactor analysis and design

diffusion plant of the Manhattan Project and subsequently followed the leader of that group to the Hydrocarbon Research Institute (where he hired Katz as an assistant). Squires was instrumental in developing a major research program in coal conversion processes, resulting in the establishment of the Clean Fuels Institute, in which five departmental members were active. The Institute was well funded and made significant contributions to the technology of coal conversion. Graff became director the Institute after Squires left in 1976, and the program continued for ten additional years until research in clean coal technology was effectively abandoned by the U.S. Department of Energy.

Pfeffer, in the meantime, collaborated with Sheldon Weinbaum from the Mechanical Engineering Department to establish a program on fluid-mechanics problems in packed beds and particulate systems. This activity evolved in two directions. One was to reinforce the tradition in fluidization initiated by Squires. In 1977, this direction was strengthened by the arrival of Herbert Weinstein, a 1956 graduate of the department who established a very effective collaboration with Exxon. Gabriel Tardos, who started his work with Pfeffer in fluid-particle systems and who joined the faculty in 1979, has become a recognized expert in the field of powder technology. In 1992, Tardos developed the first option in powder science and technology integrated into a chemical engineering undergraduate curriculum.

The other direction in which the Pfeffer/Weinbaum collaboration evolved resulted in a very successful research program on biomedical issues. This program has had a strong impact on the field. Weinbaum, a member of the National Academy of Engineering, is now codirector of the Center for Biomedical Engineering, which is a collaborative center with the Hospital for Joint Diseases and the Hospital for Special Surgery. A new PhD program in biomedical engineering was established last year at City College, and the participants include a number of chemical engineering faculty members and students.

David Rumschitzki (who joined the department in 1983) has been, partly in collaboration with Weinbaum, studying the transport of water and macromolecules such as lipoprotein cholesterol from the blood into the walls of the vessels and the kinetics of cholesterol binding to extracellular matrix. These events are among the earliest in atherosclerosis, and they certainly play a large role in vessel and graft susceptibility to disease. He also collaborates with researchers at Exxon on the mechanism of catalyst coking. Carol Steiner, who joined the faculty in 1985, has been examining applications of unique polymeric hydrogels (developed in

her group) to sustained and targeted drug delivery. Lane Gilchrist, who is currently in his second year on the faculty, is working on the development of biomaterials from cellular components in cooperation with the Hospital of Special Surgery.

A rare opportunity occurred in 1978 when Benjamin (Veniamin) G. Levich was able to leave the Soviet Union. Levich was a renowned physicist, a member of the Russian Academy of Sciences, and, most importantly, a prominent "Refusenik." Robert Marshak, the president of City College and a prominent physicist, moved quickly and successfully to have Levich appointed as one of the five New York State Albert Einstein Professors in Science. An interdisciplinary Institute of Applied Chemical Physics was established under Levich's direction. Levich's primary appointment was in the Department of Chemical Engineering and he was well known in the chemical engineering community for his landmark monograph, "Physicochemical Hydrodynamics," which appeared in translation as one of the first books published in Neal Amundson's Prentice-Hall series on chemical engineering. (He also held appointments in physics and mechanical engineering.) Levich quickly established himself as a major figure in chemical engineering in the United States and his personal influence and that of the Institute was a major stimulus for the college and especially for the department.

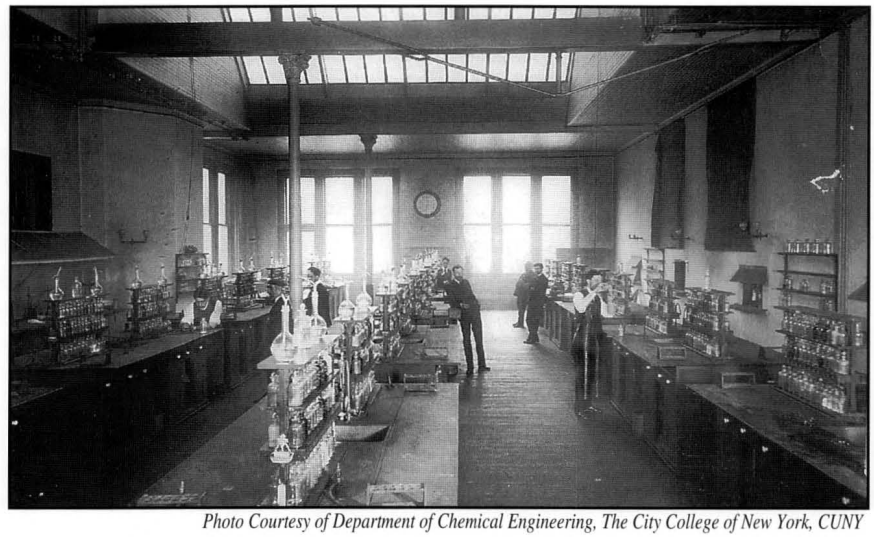


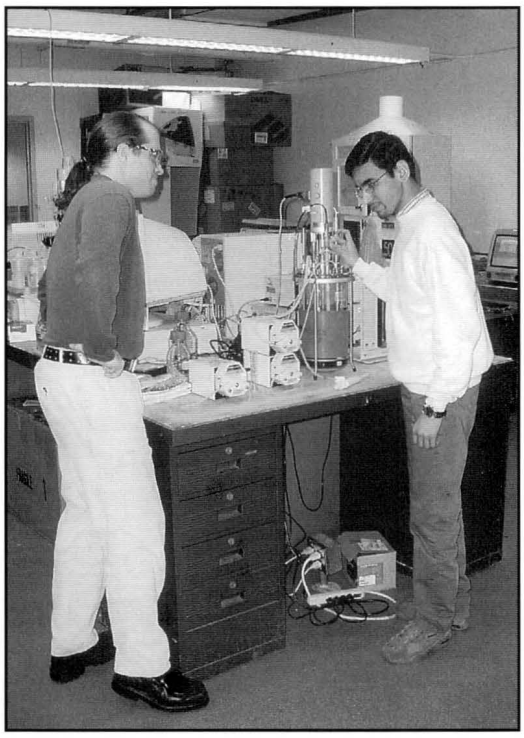
Photo Courtesy of Department of Chemical Engineering, The City College of New York, CUNY

The original Free Academy chemical laboratory in downtown Manhattan, constructed to the latest standards in 1883.

Levich passed away in 1987, and Andreas Acrivos was induced to come to the college in 1988 to fill the Einstein Professorship and become director of the Institute, which was renamed the Benjamin Levich Institute for Physicochemical Hydrodynamics. Acrivos, a member of the National Academy of Engineering and of the National Academy of Sciences, had previously been on the faculties at Berkeley (1954-62) and Stanford (1962-1988). One of the giants of modern fluid mechanics and chemical engineering transport processes, he led the Institute and reinforced its ties with chemical engineering until his formal retirement earlier this year—the term "formal" indicating he is continuing his influential research program on the mechanics of particulate suspensions, as well as his active participation in departmental affairs. In fact, he took on two new PhD students this past fall and gave an informal but well-attended lecture course during the spring. Acrivos held joint appointments as professor of physics and professor of mechanical engineering, and he was editor of the *Physics of Fluids* from 1982 to 1998.

Morton Denn came to the college in 1999 and succeeded Acrivos the following year as the Einstein Professor and as director of the Levich Institute. A member of the National Academy of Engineering, Denn began his career at Delaware, where he became the Allan P. Colburn Professor. He subsequently spent 18 years at Berkeley, where he served as Chemical Engineering Department chair and head of materials chemistry in the Materials Sciences Division of the Lawrence Berkeley National Laboratory. He is the editor of the *Journal of Rheology* and previously served as editor of the *AIChE Journal*. His involvement with CCNY chemical engineering goes back to his PhD dissertation on optimization, which included an analysis of some work by Stanley Katz. In 1986, he coauthored a book chapter with Shinnar on coal gasification reactors. In that same year, with his student, Bousfield, and collaborators Keunings and Marrucci, he published the first complete analysis of the 1969 City College experiments on viscoelastic jet breakup. His current research focuses on polymer processing and polymer blends and interfaces. Denn's career was highlighted in an article in *Chemical Engineering Education* in the spring of 1996. He also holds a joint appointment as professor of physics.

The Levich Institute has seven full-time faculty members (including Acrivos) with appointments in the Departments of Chemical Engineering, Mechanical Engineering, and Physics, and a number of associated faculty. All Levich faculty and students are housed in the engineering building. A common theme within the Institute is the behavior of complex fluids and interfaces. Institute member Charles Maldarelli joined the Chemical Engineering Department in 1980 and he has maintained an active and internationally recognized research program in interfacial fluid mechanics, which has led



Doctoral student Manoj Sharma and Professor Lane Gilchrist check the bioreactor. Microorganisms grown in this reactor will be harvested to recover self-assembling proteins used in the construction of specialized biomaterials.

to the development of methods for the measurement of dynamic surface tension and a theory for remobilizing fluid interfaces retarded by the absorption of surface-active impurities. This activity is part of a broad program in surface behavior, some of which is done in collaboration with Joel Koplik, a Levich Institute physicist interested in molecular simulation of fluid and transport problems. Koplik also collaborates with Acrivos. Maldarelli and Rumschitzki, who is an associated faculty member in the Levich Institute, also have a collaboration on nonlinear stability issues in jets and two-phase flows that are relevant, for example, in oil recovery.

Alexander Couzis joined the Chemical Engineering Department in 1994 after several years at International Paper and a year as an Industrial Fellow at the University of Minnesota's Center for Interfacial Engineering. Couzis is also an associated faculty member in the Levich Institute. His research focuses on the absorption of surfactants at the solid-liquid interface for the purpose of engineering materials with specific surface properties. Applications include control of wetting behavior, adhesion, novel sensor development, and templated crystallization. Couzis and Maldarelli have spearheaded the department's efforts in nanotechnology and nanoscience, including a collaborative program with Dupont, under the NSF nanotechnology initiative, to develop a new molecular design approach for the control of polymorph-selective crystallization using self-assembling surfactant molecules (SAMs) to functionalize solid surfaces as nanotemplates for heterogenous and selective nucleation and growth of three-dimensional crystals.

Other Levich faculty include Jimmy Feng, a mechanical engineer who did a chemical engineering postdoc at Santa Barbara with Gary Leal, and who is interested in non-Newtonian fluid mechanics, and Mark Shattuck and Hernan Makse, young physicists in the Levich mode who are initiating research programs in granular materials. Weinbaum is also a member of the associated faculty at the Institute.

Individual faculty members have other interests in addition to the broad themes sketched above. Materials Science and Engineering is an interdisciplinary effort at City College and includes a major activity in photonics. Leslie Isaacs, who joined the Chemical Engineering Department in 1974, collaborates on materials issues with faculty in physics, mechanical engineering, and civil engineering. Roberto Mauri returned to Italy this year to join the chemical engineering faculty at the University of Pisa, but he holds a position as research professor and will spend summers at City College continuing a collaboration with Shinnar on extraction using spinodal decomposition of binary solvent mixtures.

Students at any urban institution benefit from the resources of their "city campus." City College students, however, benefit more than most, for their city campus is bigger and more varied than any other, including some of the world's greatest cultural resources. These resources include, as an incomplete list, the New York theaters (both Broadway and Off-Broadway), the Lincoln Center for the Performing Arts, the Metropolitan Museum of Art, the Museum of Modern Art (MOMA), the American Museum of Natural History, and the renowned Bronx Zoo and Botanical Garden complexes. Recreational opportunities abound in all the boroughs of the city and in the surrounding suburbs. City College is easily accessible by public transportation from any location in the city and nearby communities, so students have the opportunity to live in a variety of urban neighborhoods while taking full advantage of New York City's unmatched cultural life.

The hundreds of national and multinational firms headquartered in New York City and nearby communities constitute one more resource of particular value to students. Contact with businesses and governmental agencies is very beneficial, and many of our students spend one summer as interns in industrial laboratories.

Excitement and opportunities have always attracted people to this dynamic city. The famous, the infamous, and countless others in the melting pot of Manhattan find a forum here. On any given day, you can find numerous important people making public appearances in the city. On those same days, you need only stop by the local corner market or a Central Park fountain to hear the orations of some slightly less famous, but just as appealing, concerned citizens. ❐