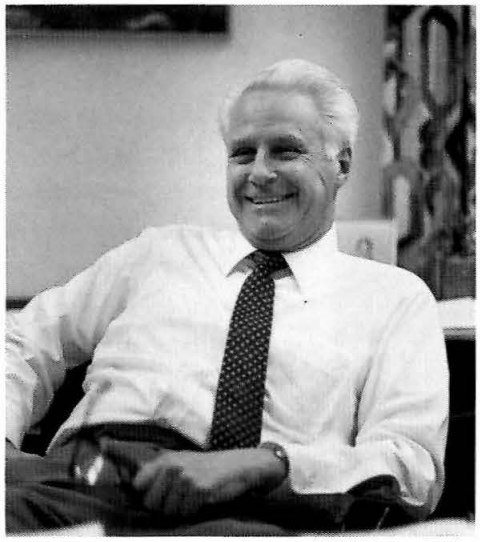
SUMMER UNDERGRADUATE RESEARCH FELLOWSHIPS

1990 ANNUAL REPORT

California Institute of Technology

Again this year, for the sixth consecutive year, a generous gift from AMETEK, Inc., has been used to offset production costs associated with the publication of the SURF Annual Report. As before, we are deeply grateful to Caltech alumni Robert L. Noland (BS41ME), President, and Alfred Schaff (BS41ME), Assistant to the President (retired), for their personal support as expressed through AMETEK.

IN MEMORIAM



Edward J. Baum
March 3, 1920 - February 14, 1990

It was with great sadness that we learned of the death of Ed Baum in February. Ed, a long-time supporter of the SURF program, served as SURF liaison in the Development Office from 1982 until 1989. He was dedicated to the vision of the founders of the program and committed to the students. His unflagging enthusiasm, his insight, his attention to detail, and his nurturing during SURF's early years will influence the program for many years to come. We deeply miss Ed's ebullience, his wisdom, and, especially, his friendship.

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DEDICATION

SURF-90 is dedicated to Fredrick H. Shair, Professor of Chemical Engineering at Caltech, founder of the SURF program in 1979, and program director until 1989. His vision for educational enhancement and his profound commitment to the formation and welfare of young people have helped many students towards the achievement of their personal and professional goals. Through the SURF program, teaching, and other institutional involvement, he has greatly advanced the quality of education at Caltech. With appreciation for his example and gratitude for his achievements, we dedicate the 1990 SURF program to Professor Shair.

PRESIDENT'S MESSAGE

This summer marked the SURF Program's twelfth year, twelve years of remarkable achievement and growth. As I have listened to the SURF Seminars each year that I have been President, I have come to value the achievements of the students and their research sponsors more and more. The SURF experience provides an individual research-oriented counterpoint to the normal classroom experience most students encounter. It also fosters collegiality between the faculty sponsor and the student—between mentor and protégé. This combination creates a team that produces new ideas, discovers new knowledge, and provides superlative mutual stimulation.

The success of the SURF program depends on the active involvement of many people. This year more than 400 individuals including students, research sponsors, administrative staff, donors, and other friends participated on the Caltech SURF team. I want to express my deep gratitude to everyone who participated, and especially those who have given time, money, wise counsel, and leadership to enrich the students and the program. Our SURF program is one of the activities that has helped Caltech to achieve its place of superlative quality and excellence in the academic world, and I congratulate those who have made it possible.

Thomas E. Everhart

Thomas E. Everhart
President
California Institute of Technology

Report from the SURF Board

Arthur Adams

My heartiest congratulations to the 145 SURF students and their research sponsors! I am very thankful for the opportunity to participate on the SURF team with this outstanding group of enthusiastic and talented scholars.

As I complete my term as Chairman of the SURF Board, I feel a warm personal sense of gratitude for my association with the other members of the Board as we strive together to help achieve the goals of the SURF program. I have enjoyed working with Loyd Sigmon, Vice Chairman of the Board, with Terry Cole and the other members of the SURF Administrative Committee, and with the capable SURF staff.

Together we have accomplished much this year. We have added significantly to endowment funds; individual and corporate giving to current operating funds has continued at a substantial level. Our mission for next year will be to increase both endowment contributions and annual individual and corporate gifts to current operating costs in an effort to put the SURF program in a stronger financial position.

Last February we were all saddened to learn of the death of Ed Baum. Ed, one of the original members of the SURF team, lent his creativity, his enthusiasm, and his commitment to the formation of the program. The Board joins the members of SURF-90, their research sponsors, and the Caltech community in a deep expression of sympathy to Ed's family.

As we look ahead to 1991, we anticipate the National Conference on Undergraduate Research which will bring 1500 students, faculty, and administrators to the campus in March. It is appropriate that the institution which created SURF should encourage independent research among undergraduates nationwide.

We look forward to another outstanding SURF year and hope that you will continue to be a valued and important contributor to SURF-91.

Report of the SURF Administrative Committee

Terry Cole

It has been a great pleasure to work with the new SURF Director, Carolyn Merkel, the SURF Board, and its Chairman, Art Adams. Our committee consisting of faculty, JPL, and administrative staff is dedicated to strengthening the SURF program and maintaining it as the nation's leading undergraduate research program.

The overarching goal of SURF is to enable Caltech undergraduates to carry out independent research under the leadership of outstanding researchers in a variety of environments and to assure funding for every student with whom a sponsor enthusiastically wants to work. This goal has been the cornerstone of the program since its inception.

Among our objectives for the future are the increase and stabilization of the funding base, the addition of selected undergraduates from other universities to the SURF program, broadening the opportunities for Caltech SURFers to spend their fellowships at other universities as well as government and industrial research laboratories, and increasing minority participation in the program.

The SURF team is working to bring these objectives to fruition. The first major step towards ensuring a continuing robust financial position is the establishment of endowments. We especially thank Hugh Colvin and Samuel Krown for their leadership in this area.

The Institute has pledged increased financial commitment to SURF, and we thank the administration for this tangible support of the program. The Development Office is spearheading new fund-raising strategies. The SURF Administrative Committee will develop a long range plan. Together we are establishing a solid foundation for the future of undergraduate research at Caltech.

THE BEAUTY OF SURFING AT CALTECH/JPL

By Fredrick H. Shair

Excerpts from his speech at the SURF Kickoff Dinner, January 30, 1990

The beauty in science, engineering, and mathematics has many dimensions revealed through humankind's use of science as a process to understand nature and ourselves; the mystery of how a few elegant principles can lead to a deeper understanding of relatively complicated phenomena and patterns; the power of engineering and science to broaden our vision of the unseen—from the microscopic to the cosmic; the many ways in which persons from widely diverse cultural and disciplinary background find common ground is by collaborating on problems of mutual interest.

During the past 18 months, events throughout the world were as rapid and dramatic as they were unexpected. Although not widely publicized, technology played a most important role in the fall of the Eastern Bloc governments. There was wide use of videotapes and Cable News Network broadcasts picked up by satellite dishes. With respect to the democratic movement in China last spring, it is estimated that 30,000 FAX machines provided a crucial link for reformers to communicate with the outside world. In a real sense, technology seems to permit the development of an "information middle class." An interesting philosophical question is: "Will advances in science and engineering inevitably drive societies toward democracy?"

Although not widely publicized, advances in science and engineering were just as important and just as amazing as the political changes we have witnessed.

In fact the December 22, 1989 issue of *Science* selected the DNA polymerase molecule, the molecule that drives the polymerase chain reaction (PCR), as the molecule of the year. Using PCR techniques tiny bits of embedded, often hidden, genetic information can be greatly amplified into large quantities of accessible, identifiable, and analyzable information. A single cell now provides enough information for analysis: a single hair can be used to unambiguously identify any individual.

The most mind boggling chemical synthesis went to researchers who correctly synthesized the compound called polytoxin. Polytoxin has a chemical formula of $C_{129}H_{223}N_3O_{54}$ and has 10^{21} possible isomers. Natural polytoxin, a potent toxin, is extracted from coral; its only known source is a coral that lives in a six-foot by two-foot tidepool near Hana on Maui. Its synthesis has yielded new procedures that can be used to synthesize other macromolecules important for medicine.

The scientific and technical advance with the most universal appeal went to our own Ed Stone and his colleagues at JPL and elsewhere who developed Voyager 2. Neptune was named planet of the year. The photos of Neptune and Triton were truly spectacular. Voyager 2 was a dramatic synthesis of science and engineering that captured the imagination and raised the human spirit.

Last November two researchers at the Harvard-Smithsonian Center for Astrophysics reported the largest coherent structure yet seen in the universe. Called the Great Wall, this structure has a width of at least 500 million light years. Maarten Schmidt, Francis L. Moseley Professor of Astronomy, tells me that the universe is now known to possess a crystalline nature which is challenging our understanding of how the universe evolved following the big bang.

A major reinterpretation of the data collected from the Burgess Quarry, a limestone quarry tucked into the Canadian Rockies some 8000 feet above sea level, is challenging our concepts regarding evolution of life on earth.

The concepts of chaos and fractals are rapidly filtering through several fields. Researchers recently reported that "the healthy heart beats to a rhythm that is ever-changing—but that can become periodic at the onset of disease." Physiologists now believe that chaotic dynamics may underlie the formation of many fractal-like structures in the human body.

Unlike some disciplines, most fields of science, engineering, and mathematics are developing very rapidly. This growth is also reflected in the increased rate of publishing. As pointed out in the publication, *Opportunities in Chemistry,* over eight million chemical compounds have been synthesized and characterized; and the doubling time for new compounds is less than 11 years. Between 1977 and 1981 there were 14 feet of chemical abstracts published. In 1959, there were four volumes of *Physical Review* spanning about one and a half feet of library shelf space. The shelf space needed for the *1989 Physical Review* spans more than fifteen feet!

To paraphrase a statement made by Bob Sharp, Robert P. Sharp Professor of Geology, Emeritus, exploration is one of humankind's most noble endeavors when pursued at its best primarily for the joy and satisfaction of venturing into the unknown. The intellectual frontier appears to be constantly expanding and there is room for all, including ambitious undergraduates.

The faculty at Caltech, the staff at JPL, the administration, the students, and the rest of the extended Caltech family are an international resource. And SURF is an excellent expression of the historical thrust of Caltech/JPL. In the final analysis, research is a truly human adventure in which there is room for all to participate, directly and indirectly. The JPL staff and Caltech faculty are second to none in the world with respect to the opportunities they make available to young people through SURF. In addition to being at the leading edge, the informal and friendly characteristics of the total Caltech community are as refreshing as they are remarkable.

Participating in the development of SURF with the faculty, JPL staff, the students, the SURF Board and SURF Administrative Committee, and working closely with Art Adams, Hugh Colvin, Samuel Krown, Betty Nickerson, Carolyn Merkel, Joan Spears, Ed Baum, and David Goodstein has been a truly profound experience for me. The members of the SURF team deeply appreciate the special encouragement given to SURF by the Caltech faculty, administration, and JPL.

I deeply miss the insight, encouragement, and humor that Ed Baum, Bill Lang, Lester Lees, David Welch, and Oliver Wulf gave to me. I miss playing doubles tennis with Ernest Swift. I also miss the enjoyable and stimulating discussions that I was fortunate to have with Jon Matthews and Richard Feynman during our sailing trips to freshman camp.

We are neither able to shape the future with much certainty, nor are we able to stay around very long to see what happens. The best we can do is to help our young people develop (I) a yearning for discovery, (II) a spirit of openness, and (III) a deep sense of compassion for all of life. There is no better handshake with the future. It is fitting that we institutionalize those values we hold dear—it is fitting that we institutionalize those values at the world's leading institution. And that is the beauty of SURFing at Caltech/JPL.

The Heritage of SURF

Every successful academic project starts with an idea that draws to it people devoted to putting it into operation. The Summer Undergraduate Research Fellowships (SURF) program at Caltech has become an outstanding example of those two requirements in action. The program was created by Fredrick Shair, Professor of Chemical Engineering, who realized that undergraduates at Caltech needed greater interaction with the faculty, that they deserved increased hands-on experience with research, and that one way to achieve both of those ends was to combine them.

Under Fred Shair's direction, SURF began with funding from the Caltech Prize Fund in 1979 with 18 students and 17 faculty sponsors, experimenting with a program that was designed to contain all the elements of a professional research project. Each applicant found a faculty member who was willing to collaborate in defining a project that the student could work on independently over ten weeks in the summer. The faculty member had to be willing to provide laboratory space, computer time, supplies, and logistical support. Each student would write and submit a proposal to be reviewed for funding. Those who were accepted would receive a stipend during ten weeks of the summer. At the end of that time, each was expected to describe his or her results at a scientific meeting. In some cases, it was expected that research would result in published papers.

Students have discovered how exciting front-line research can be. They apply what they have learned in the classroom to real-life projects—seeking solutions to unanswered questions. They gain insight into what a professor's professional life is like, and about the kind of career they might like to pursue in the future. Equally important is the interaction between students and professors that the SURF program provides. Research sponsors are more than qualified teachers for undergraduates, they are mentors. The mentor-protégé relationship encompasses not only the research project but also the relationships within the research group, the economics of research, and research ethics. The student-sponsor relationship is one of the most important aspects of the SURF experience.

However, SURF not only benefits the students. Over 20% of SURF students become co-authors on articles in the open scientific literature and are, therefore, contributing substantially to the research of their sponsors. Through the Speakers Bureau and the Outreach Project to the Schools, SURFers share their enthusiasm for science and help to further the public's scientific awareness.

The Institute benefits from the SURF program. Ninety-three percent of the 1989 freshman class said they chose Caltech because of the chance to do research. The program helps to build bridges between students and faculty; between Caltech and JPL; between the Institute and alumni, donors, the community, and the local schools. Some departments have recruited graduate students through the SURF program.

SURF has grown beyond almost anyone's expectations. A total of 145 students, including 29 from other campuses, undertook projects this year—supervised, encouraged, and counseled by 105 faculty, JPL, and off-campus sponsors. In addition to growing numbers, the geographical spread of the research also expanded as several of the students worked in such diverse places as Italy, China, South Africa, Iowa, and Ohio.

Over the years, other changes have taken place in the program. Noontime seminars, leadership roundtables, and communications workshops have been added. The stipend has been increased, and funding for the program has become more diversified. Individuals, foundations, and corporations have enthusiastically supported SURF and the need for quality research training at

the undergraduate level. In addition, many find that such support can result in reciprocal benefits to both the donor and the student.

None of this would have been realized without Fred Shair's original vision for an undergraduate research program at Caltech. Serving as director during SURF's first eleven years, Fred brought together a dedicated team, laying the groundwork for the phenomenal growth and success of the program. Under his leadership SURF flourished and matured.

Many devoted volunteers joined the SURF team, including an administrative committee, the SURF Board, speakers, faculty and JPL technical staff members, Caltech administrative staff, and, of course, the enthusiastic and hardworking undergraduates who are the reason for the program's existence and the reward for the effort.

SURF provides a new dimension to the process of undergraduate education. Graduates of SURF, with their sophisticated and practical knowledge of how to conduct research, have a marked advantage as they embark on their career paths, apply to graduate schools, or look for jobs in industry.

SURF-90 IN REVIEW

Carolyn Merkel

Financial Notes:

SURF's financial status was strong in 1990. The SURF Administrative Committee was able to fund all the top-ranked proposals. The program received funding from the Institute, JPL, faculty grants, individuals, income from the endowment, corporations, and foundations—including the National Science Foundation. Special thanks to our donors, faculty, and JPL for their increased financial commitments to SURF-90.

Endowments:

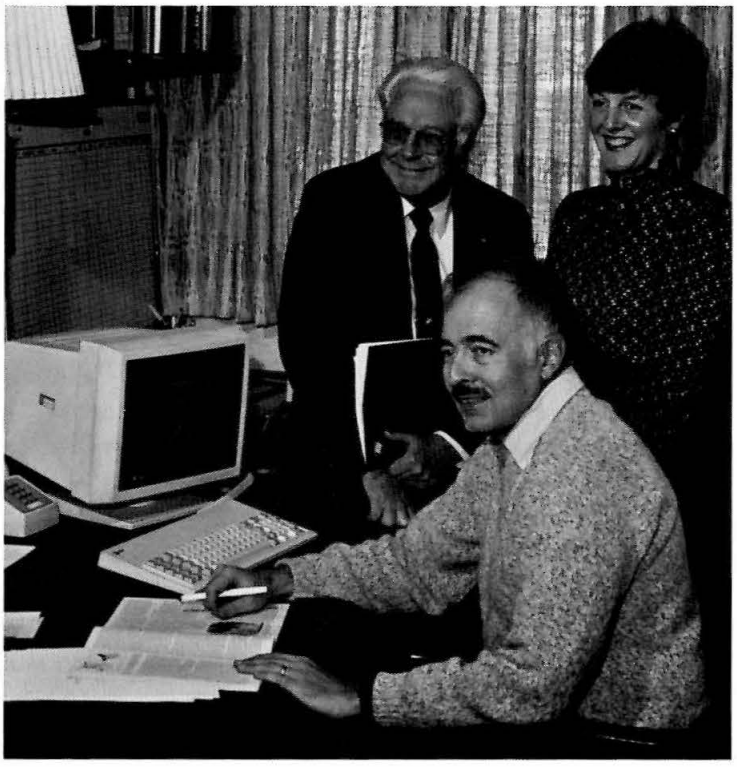
To commemorate the retirement of Toshi Kubota, Professor of Aeronautics, his former students established an endowment in his name. We thank Drs. John Lewis and Thomas Tyson for their leadership in creating this endowment. Ensuring the continuation of an excellent educational opportunity for future students is an outstanding way to honor Professor Kubota's many years of dedication to the intellectual formation of his many protégés.

Eighteen endowments have been set up for a total value exceeding $1.2 million. The income from each $50,000 endowment provides funding to support one SURF student each year in perpetuity.

Can you do Research for a Living?

In July and August, lively discussions were held with two small groups of SURFers to solicit their suggestions for a series of seminars on various aspects of research careers, to be piloted next summer. Topics included: entrance requirements for careers in research; opportunities (and differences) in university, industrial, and government laboratories; selecting and gaining admittance to graduate schools; getting and keeping a job in research; and research ethics.

The discussions were led by Bill Whitney of JPL, a member of the SURF Administrative Committee; and Julie Kornfield, a SURF student in 1982 and now Assistant Professor of Chemical Engineering. Other participants included Terry Cole of JPL, Chairman of the Administrative Committee; Paul Robinson, also from JPL; Fred Shair,



Summary of the 1989 SURF Class

Divisions and Options	*Number of Sponsors*	*Number of Students*	*Number of Non-Caltech Students*
Biology	13	17	2
Chemistry and Chemical Engineering			
Chemistry	14	23	5
Chemical Eng.	2	3	1
Engineering and Applied Science			
Applied Microbiology	1	2	1
Applied Physics	3	5	
Civil Engineering	1	1	1
Computer Science	3	3	
Electrical Engineering	5	5	
Environmental Engineering Science	1	1	1
Materials Science	2	3	
Mechanical Eng.	1	1	
Geological and Planetary Sciences			
Geology	2	4	
Planetary Science	2	4	1
Humanities and Social Science			
Economics	2	2	
Geography	1	1	
History	3	3	
Literature	1		
Physics, Mathematics, and Astronomy			
Physics	13	15	1
Mathematics	4	4	
Astronomy	5	5	
JPL	23	39	16
Off-Campus	3	4	
TOTAL	105	145	29

We welcomed 29 students from other universities to participate in SURF-90. Colleges represented included: Amherst; Brown; Bryn Mawr; California State University at Fullerton; Carnegie Mellon; Columbia; MIT; Notre Dame; Occidental; Pomona; Princeton; Reed; Thessaloniki (Greece); Stanford; University of Southern California; University of California at Berkeley, Los Angeles, San Diego, and Santa Cruz; University of Colorado; University of Maryland; and University of Texas at Austin.

Dean of the School of Natural Science, California State University at Long Beach, on leave from Caltech; and Carolyn Merkel, Director of the SURF program.

SURF Noon Seminar Series

Each Wednesday during the summer, members of the Caltech faculty or JPL technical staff presented a broad overview of each of their areas of research. In addition to the SURF students, members of the Caltech/JPL community attend the seminars—including faculty, staff, and friends of SURF.

Speakers for the summer were:

Pamela Bjorkman, Assistant Professor of Biology and Assistant Investigator, Howard Hughes Medical Institute, "An Atomic Resolution Picture of HLA: A Molecule that Helps You Get Rid of A Cold"

Moustafa Chahine, Chief Scientist, JPL, "Mission to Planet Earth"

John Hall, Associate Professor of Civil Engineering, "Bridge Engineering Aspects of the Loma Prieta Earthquake"

Steven Koonin, Professor of Theoretical Physics and Chairman of the Faculty, "What's New in the Nucleus?"

Julia Kornfield, Assistant Professor of Chemical Engineering, "A Short Talk about Long Molecules"

John Ledyard, Professor of Economics and Social Sciences, "An Experimental Approach to Managing Space Stations"

Thomas McDonough, Lecturer in Engineering, "Read My Lips! How NOT to Give a Technical Talk" and "Read My Papers! How NOT to Write an Article"

Peter Patton, Deputy Manager, Supercomputing Project, JPL, "Computer Applications Beyond the Sciences"

David Stevenson, Professor of Planetary Science and Chairman, Division of Geological and Planetary Sciences, "How Many Stars Have Planets?"

David Van Essen, Professor of Biology and Executive Officer for Neurobiology, "Information Processing in the Primate Visual System"

JPL Seminar Series

Each Friday during the summer, members of the JPL technical staff presented summaries of their work to the JPL SURF students.

Speakers included:

Robert Clauss, Systems Development Program Manager, TDA Office, "MicroMITES (SURFSAT) and the Deep Space Network"

Charles Elachi, Assistant Laboratory Director, Office of Space Science and Instruments, "Space Radar Observations of Earth andPlanetary Surfaces"

Margaret Frerking, Supervisor of Advanced Devices Group, Microwave Observational Systems, "Submillimeter Astrophysics Space Missions"

Michael Hecht, Member of the Technical Staff, "Ballistic Electron Emission Microscopy"

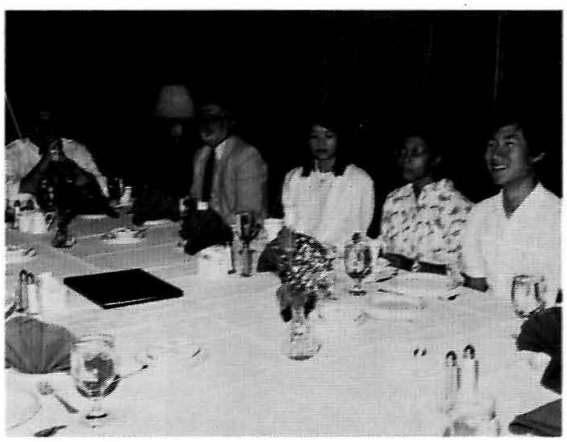
Kevin Hussey, Technical Group Supervisor, "Science Data Visualization and Animation"

Ralph Kahn, Research Scientist, "Toys in Space"

David P. Miller, Supervisor, Robotic Information Systems, "Robotic Intelligence"

Paul Penzo, Staff, Mission Design Section, "Tether Applications in Space"

Donald Rapp, Division Technologist, Mechanical Systems Engineering and Research Division, "How to Discover Other Solar Systems"



SURF Roundtables

Colonel Chuck Thomas, District Commander of the U.S. Army Corps of Engineers, led a group of students in a roundtable discussion about the evolution of the Corps and some of the projects the Corps is undertaking. Of special interest were the ecological projects such as reclaiming wetlands near Newport. Victor Veysey, Director Emeritus of the Industrial Relations Center, also participated in the roundtable.

Robert Shafer, member of the SURF Board and retired management consultant, led a roundtable discussion with 20 students. Using themes from the Old West, he applied leadership characteristics to modern-day corporate management skills. Others in attendance were Arthur Adams, Samuel Krown, Betty Shafer, and Loyd Sigmon.

Other roundtable discussions scheduled for later in the year will be led by representatives from SURF's corporate sponsors. A group of Caltech faculty and JPL technical staff women will meet with the women of SURF to discuss career and family issues.

SURF/Caltech Y Program

The Caltech Y Summer Executive Committee under the chairmanship of Lan Smith (SURF 89 and 90) met weekly to plan and organize social, cultural, and community activities. Some of the activities included: weekly movies in the Y Lounge; get-acquainted-barbecue on Orientation Day; parties; summer sports day; and trips to Raging Waters, Hollywood Bowl, Ice House, Magic Mountain, and to the Los Angeles Coliseum to see Nelson Mandella.

Not all activities were just for fun. Several students spent two days painting cottages at Five Acres, a home for abused children. The SURFers took a collection to contribute to the *Los Angeles Times* Camp Fund. Catherine Ridder-White, MFCC, administered the Meyers-Briggs Type Indicator test, which measures personality preferences, and discussed the characteristics and typical career choices of various temperament types.

The SURF/Caltech Y program has become an important part of the summer program. Thanks to Joan Spears, SURF Assistant; Lucy Guernsey, Executive Director of the Y; Brian Redin, Student Events Coordinator; and Bernice Reda, Administrative Assistant in the Y; and to the Summer Excomm for an outstanding, full, fun, and varied schedule.

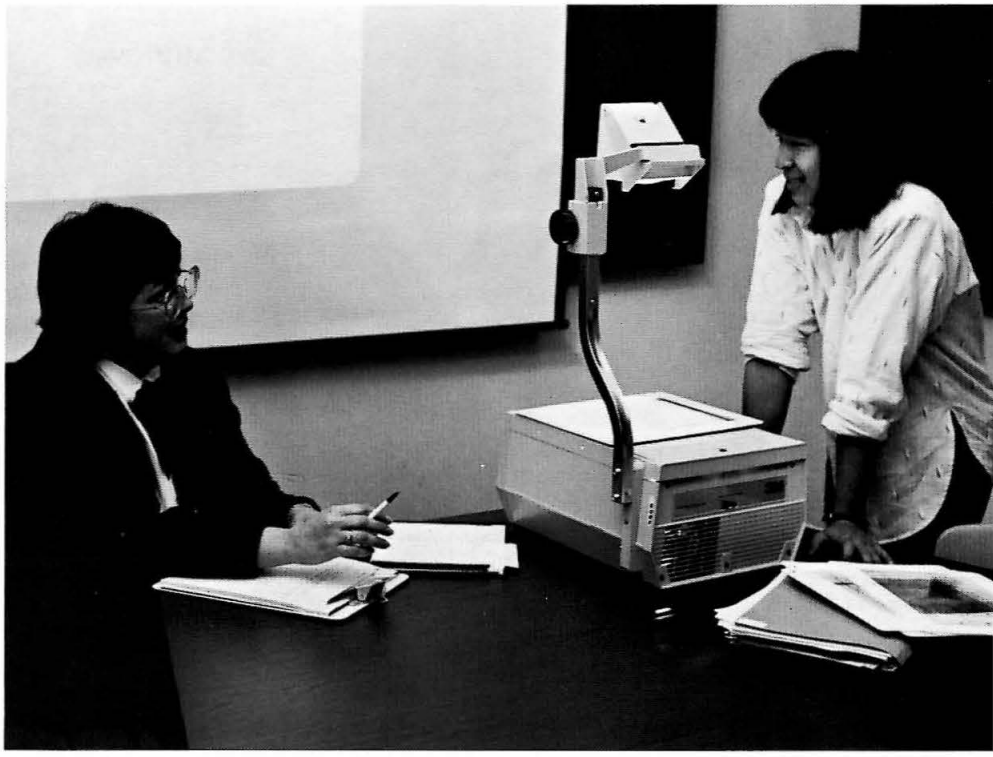
The Students Speak

The third Saturday in October is traditionally the culmination of the annual SURF program, SURF Seminar Day. Each SURF student gives an oral presentation of his or her research project to an audience of faculty, research sponsors, parents, peers, donors, and alumni.

The fourteen parallel sessions this year were preceded by a luncheon in Dabney Garden. President and Mrs. Everhart hosted a reception following the presentations to honor the students and their research sponsors.

Fifteen to twenty students interested in speaking to campus and community groups, or to students and teachers in local schools, comprise the SURF speakers bureau. The group meets monthly to rehearse talks and to prepare for presentations in a variety of settings and to diverse audiences—both technical and non-technical. Students may give a major presentation or a 5-minute synopsis of their work.

Under the direction of Jean Cass, the SURF Speakers Bureau was very active this year, with students giving a total of 100 presentations to various groups including Caltech's Board of Trustees, the SURF community, donors and potential donors, Caltech alumni, and civic groups. Several SURFers gave talks and demonstrations at five local elementary schools.



Fourteen students travelled to Union College in Schenectady, New York, to present their work at the National Conference on Undergraduate Research. En route to the conference, four students stopped in Chicago with Joanne Clarey, Director of Corporate Relations, to give their talks and to tour

Amoco Corporation and Abbott Laboratories. Three students travelled with Terry Cole to General Motors Corporation and Ford Motor Company

in Detroit to report on their research to these contributing corporations. Six students met with the technical staff at Xerox Corporation in Rochester, New York, gave their talks, and received a tour.

The large—and growing—number of requests for speakers is an indication of the value the community places on this important outreach.

Fifth National Conference on Undergraduate Research

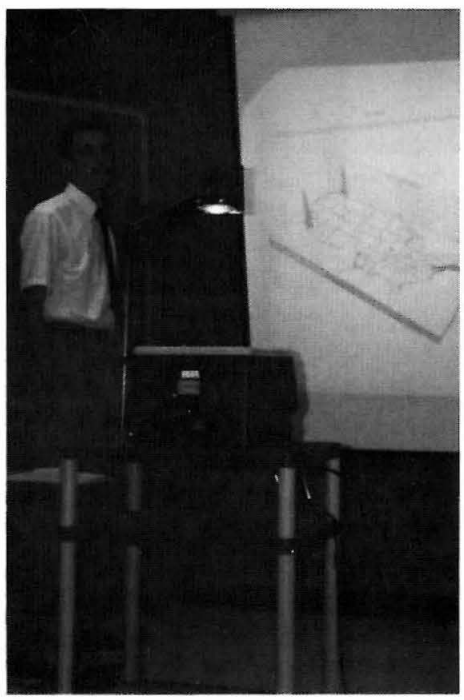
EUREKA! That exclamation of discovery uttered by Archimedes twenty-one centuries ago (be it apocryphal or not) still symbolizes the magnificent feeling of triumph in achievement, in solving a problem, in finding an answer.

Accordingly, EUREKA has been chosen to express the spirit of the Fifth National Conference on Undergraduate Research, which will be held from March 21-23, 1991, at Caltech. Here some 1500 participants—approximately 1000 of whom will be undergraduates from over 200 colleges and universities throughout the country—will gather to share with one another the excitement of their discoveries and the satisfaction of their scholarship.

The lively exchange of ideas and information that takes place at the conference has been called "a significant celebration of undergraduate intellectual life." Indeed, the range of academic disciplines included is in itself significant—the arts, humanities, social sciences, natural and physical sciences, business, mathematics, education, and engineering. At the conference, students have the opportunity to present papers or exhibits to a national audience, and to engage in scholarly discussions with colleagues in their own fields as well as with undergraduates in other disciplines.

Dr. D. Allan Bromley, Assistant to the President for Science and Technology; Mr. Ray Bradbury, Author; Dr. Evelyn Fox Keller, Director of the Department of Women's Studies and Professor of Rhetoric at UC Berkeley; and Dr. Leroy Hood, Bowles Professor of Biology at Caltech will give plenary talks. In addition, Mr. Robert Cowen, Science Editor of the *Christian Science Monitor*, will moderate a panel of scientists, economists, and policy makers on the opposing sides of the global warming issue.

The conference offers a unique opportunity for undergraduates to immerse themselves in this environment



of ideas, among other people who recognize that undergraduate research is essential for developing the best in creativity and imagination.

BIOLOGY

Back-Filling of Locust Schistocerca Gregaria Nerves That Lead to the Hind-Legs to Identify Cell Bodies

Snehal S. Adodra
Sponsor: Gilles Laurent

Gilles Laurent's laboratory is interested in the spiking patterns of motor nerves that control the hind legs of the Locust Schistocerca gregaria. These nerves lead back to the metathoracic ganglion, which controls the muscles used in walking. For intracellular recordings of spiking patterns, the cell bodies from which these axons emerge, were identified. The four nerves that were of particular interest, i.e. Nerves 5A, 4A, 3C3, and 3B2 were back-filled with cobalt hexammine and cobalt chloride, precipitated with ammonium sulphide and intensified with nitrate. The cell bodies and the primary neurites were then identified and drawn for further intracellular recordings.

How Do We Segment Visual Scenes? A Model of Visual Cortex

Kevin A. Archie
Sponsor: Daniel M. Kammen

Recent experimental evidence reveals coherent firing, or oscillations, in assemblies of neurons in visual cortex in response to certain stimuli. To determine what processing roles this behavior is capable of performing, we have been studying the temporal dynamics of networks of mutually interacting limit cycle oscillators. We have examined a number of distinct network topologies (focusing on two dimensional, locally coupled networks) and several different types of coupling (various functions of the phase differences between connected oscillators). We also have studied the effects of noise (uniform, "white", and "brown") in the system.

Attempts at Isolation of Novel Neural Guidance Molecules in *Drosophila*

G. Richard Benzinger
Sponsor: Kai Zinn

Fasciclin I is a neural cell-surface glycoprotein expressed on a subset of *Drosophila* neuronal surfaces during axiogenesis, suggesting a role in differential recognition and cell-cell guidance during embryogenesis. In the absence of fasciclin I, however, *Drosophila* embryos develop normal nervous systems. This research attempts to isolate novel neuronal-guidance molecules, possibly with function redundant to that of fasciclin I. Attempts to implement a mutagenesis screen designed to screen for mutations lethal only in conjunction with a deficiency in fasciclin I failed. Attempts to locate new neuronal surface molecules by recognition of glycosylations and membrane linkages characteristic to fasciclin I yielded one likely candidate glycoprotein, with an apparent molecular weight of 122 kd.

Simulating a Biological Neural Network on the Connection Machine

Dean W. Brettle
Sponsor: Ernst E. Niebur

A Connection Machine program was written for simulating a network of 16,384 neurons, each with over 1000 connections. The program simulates at the synaptic conductance level. The Connection Machine architecture and how it compares to a biological neural network are discussed. Different methods of data representation and spike propagation are compared and one is shown to be most efficient. Problems encountered in moving data efficiently to and from the Connection Machine are discussed as are their solutions. Results are presented for simulations of neurons in the cat visual system with various connection patterns. The orientation tuning of cells under the different schemes is compared.

Measurement of Potassium Currents in mRNA-injected, Internally-Perfused *Xenopus laevis* Oocytes

Gavin S. Chilcott
Sponsor: Henry A. Lester

Xenopus laevis oocytes, with their aptitude for mRNA-mediated functional expression of exogenous excitability proteins, provide a powerful assay system for the study of structure, function, and modulation of cloned excitability molecules. This preparation was used as an expression system for the cloned MBK potassium channel. Subsequently, electrophysiological data on the channel were collected using the two-electrode voltage clamp method. Small glass pipettes were used to hold the oocyte and to perfuse the interior and exterior surfaces of the membrane with solutions of controlled composition.

The Binding of ROCA1, a Monoclonal Antibody Which Defines Rostrocaudal Gradients in the Mammalian Nervous System, to Various Tissues of Adult Rat

Danny Chu
Sponsors: Paul H. Patterson and Zaven Kaprielian

The ROCA1 monoclonal antibody binds in a rostrocaudal gradient to nerves that innervate the intercostal muscles and binds to the glial cells of the nerves and sympathetic ganglia of adult rats (Suzue, T., Kaprielian, Z., Patterson, P.H., (1990). "A monoclonal antibody that defines rostrocaudal gradients in the mammalian nervous system." *Neuron* (in press)). That is ROCA1 binds to the rostral intercostal nerves with a higher intensity than to the caudal intercostal nerves. In an attempt to examine the distribution of the ROCA1 antigen in other glial cells, I examined binding of ROCA1 to cryosections of adult rat colon. I found that ROCA1 binding co-localizes with other glia markers such as glial fibrilary acidic protein (GFAP) in the myenteric plexus. In a further examination of the immunoreactivity of ROCA1 in the peripheral nervous system, I used immunohistochemistry to look for a cervical-lumbar gradient of ROCA1 binding in the spinal nerves. Such a gradient was not detected. There is, however, a possible difference in ROCA1 staining of the spinal nerves along their course to the muscles of forelimbs; ROCA1 binding is higher in the regions where the nerves fasciculate in the brachial plexus. Moreover, I showed that ROCA1 binds some non-neuronal tissues such as the kidney, and to the olfactory bulb but not to spinal cord or retina. The specific binding site of ROCA1 and the nature of the antigen will be important goals for future experiments.

Testing the NGFR Mechanism Proposed to Explain Why MAH Cells Develop a Dependence on NGF in the Presence of FGF

Samuel J. Clark
Sponsor: David J. Anderson

It has previously been shown by Chikaraishi and others that the tyrosine hydroxylase (TH) gene up regulates in response to fibroblast growth factor (FGF). With this project we are attempting to verify that observation using three variant PC12 cell lines which show graded induction of TH when exposed to FGF. In order to reliably quantitate this effect we will use an assay for chloramphenicol acetyl transferase (CAT) activity and a THCAT plasmid that we have cloned. We will transfect the variants with the THCAT construct and subject them to FGF for three days after which we will assay for CAT activity and determine to what extent FGF induces THCAT in these cells. If this experiment shows a significant reproducable induction we will go on to investigate the TH promotor in further detail.

Comparison of the Cholinergic Neuronal Differentiation Gene in Two Distant Species

Keow Lin (Lindee) Goh
Sponsor: Paul H. Patterson

The induction and maintenance of the expression of neurotransmitters and neuropeptides in individual neurons is dependent on their lineage and on factors in their environment. The Cholinergic Neuronal Differentiation Factor (CDF) is one of the environmental cues, sequenced in human, rat and mouse, that can direct sympathetic neurons to differentiate along the cholinergic pathway in vitro. By sequencing CDF in two more distant species, chicken and zebra fish, we can identify the most conserved regions in the gene. Such information can be used to search for other genes with homology to CDF that also can influence neuronal phenotype. Primers derived from rat CDF were used in the Polymerase Chain Reaction (PCR) method to identify possible CDF genes in chicken and zebra fish genomic DNA. I found several candidates for the gene and these are being sequenced

Evaluating Project SEED in the Elementary School Environment

Anna M. Jaeckel
Sponsor: James M. Bower

Project SEED is a program designed to teach elementary school students science by doing science. *Plants*, a computer simulation of corn growth, accompanies the first-grade hands-on kit Growing Seeds. We are conducting a formative evaluation of *Plants*, the initial qualitative iteration of

which is now completed. We found that first graders have difficulty interpreting text. Thus we opted for graphical representations of the growth data, visual representations of extreme weather, and an audio-visual representation of the beginning of each simulated day. This project demonstrates how much can be gained by iterative design and empirical testing.

The Study of Protein Kinetics in the Ross River Virus
Jean-Paul Kovalik
Sponsor: James H. Strauss

Ross River virus is a positive-strand RNA virus of the Togavirus family. During replication Ross River virus, like a majority of RNA viruses, translates both structural and nonstructural proteins as large polyproteins which are post-translationally cleaved into individual proteins by virus encoded enzymes. It is believed that the patterns of cleavage of the nonstructural proteins plays a major role in regulating virus growth. In genetically engineered viruses where the cleavage site between nonstructural proteins 2 and 3 has been altered, the pattern of protein processing changes and virus growth is altered. Changing the putative active site of the nonstructural viral protease gives rise to a polyprotein which fails to cleave itself. This polyprotein can be used as a substrate for assaying the activity of viral nonstructural proteinases in trans cleavage experiments.

Project SEED: Animal Adventure Game
Camilla L. Lieske
Sponsor: James M. Bower

Project SEED is an educational research program dedicated towards improving science education at the elementary school level. This is done through hands on experimentation and computer simulations. My project provides an "adventure game" world around the Corn Growing Simulation for students to explore. Animals, such as raccoons, salamanders, bats, etc., were placed in the different environments of the world, and some of their actions and reactions were developed. Other details on how the adventure game will work were determined. To accomplish this, HyperCard and the artwork of Erika Oller were used extensively.

The Characterization and Cloning of the *drop-dead (drd)* Gene of *Drosophila Melanogaster*
Ralph S. Lin
Sponsor: Seymour Benzer

Drop dead (drd) is a recessive mutation located on the X-chromosome of *Drosophila.* The phenotype is characterized by a progressive loss of locomotion and flight, eventually leading to premature death. Three alleles have been isolated: *drd*[1] (Hotta, Y. and Benzer, S. (1972) *Nature,* 240*f*, 527-535) and two others isolated from an x-ray screen. Observations through electron microscopy strongly suggest that the mutation involves a defect in brain glia. Consequently, we have crossed other mutations involving similar defects into a *drd* background, and hope to find an interesting phenotype that may shed light on the nature of glia dysfunction. In addition, quantitative studies of each allele's lethality have led us to believe that a threshold amount of *drd* gene product may be necessary for rescue. In an effort to clone *drd* we have begun a chromosome walk toward the gene. Our strategy uses inversion lines (with breakpoints either close to or inside the gene) as a means to "leap" into the vicinity of *drd.* By screening a cosmid library (~35kb/cosmid), we then can walk toward *drd.*

A Probe Into the Function of the Alphavirus Genome
Jerri H. Martin
Sponsors: James H. Strauss and Richard Kuhn

Alphaviruses have a positive polarity, single-stranded RNA genome with four regions of almost completely conserved sequence. One of these regions is a 51-nucleotide sequence in the first nonstructural protein coding segment. This region is capable of forming two hairpin structures and may act as some kind of accessory promoter for RNA synthesis. The purpose of this study is to generate mutations in this 51-nucleotide region in Ross River virus, a member of the alphavirus genus. These mutations will include both silent and missense mutations, and many will alter the stability of the hairpin loops. Analysis of the replication efficiency of the mutant viruses will provide an understanding of which regions of the hairpin structures are important for virus replication and offer insight into how this structure functions in the virus life cycle.

Sequencing and Characterization of a Vacuolar Protein Sorting *(vps)* Mutant in *Saccharomyces cerevisiae*
Steven A. McLaughlin
Sponsor: Scott D. Emr

The *vps5* gene and gene product were studied in order to gain a better understanding of vacuolar protein sorting and vacuolar biogenesis in yeast. A nested set of ExoIII deletions was produced and used to sequence the second strand of the minimum complementing fragment of *vps5* The sequence confirmed an open reading frame capable of coding an extremely hydrophillic protein of 76,000 MW. TrpE-*vps5* fusion proteins were generated and used to produce rabbit polyclonal antisera. The antisera detects a single, stable *vps5* specific protein of 76,000 MW. Preliminary fractionation studies indicate that the *vps5* protein is soluble.

Batteries, Bulbs, and Bugs: Computers in Education
Jay P. Obernolte
Sponsor: Jerome Pine

The purpose of this project is to develop software on the Macintosh microcomputer to aid in the education of grade school students. Work was done on two different programs. The first, *Batteries and Bulbs,* simulates a simple electrical workbench. Students attempt to determine the contents of six "mystery boxes" by connecting them with different combinations of light bulbs and batteries and observing the intensity of the bulbs. The second, *Bugs,* recreates the movements of animated sow bugs on the computer screen. Students administer different stimuli to the bugs, such as water and light, in an effort to determine the preferences of the bugs. The *Batteries and Bulbs* program was completed; *Bugs* remains under development.

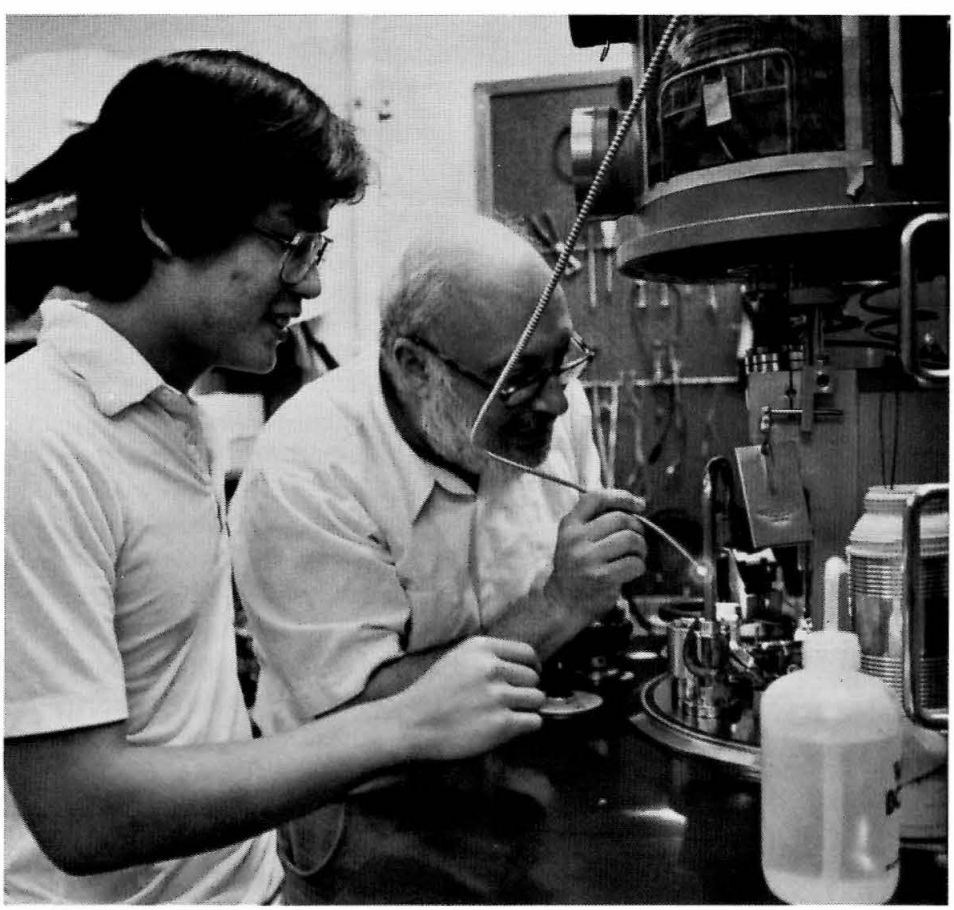
In Search of "A" Genes in the Menatode Vulva
Mimi Sengupta
Sponsor: Paul W. Sternberg

The multivulval (*muv*) phenotype in mutant Caenorhabditis elegans results from simultaneous defects in at least two independently mutable regions. Silent *muv* mutations fall into two classes, A and B, both of which are needed to result in the *muv* phenotype.

The object of this project is to isolate various new class A mutations by mutating a class B strain mutation: 1in-15 (n744). So far, eight *muv* strains have been isolated, two of which have been found, through transmission and complementation experiments, to be on the X-chromosome. The others are in the process of being mapped onto the other five chromosomes of C. elegans in hopes of identifying either new loci or new alleles of previously determined genes.

Putting Theories Back on Course: Software Simulation on a Neural Net Based Speech Recognizer
Peyjen Wu
Sponsors: John J. Hopfield and Douglas A. Kerns

The objective of this SURF project is to develop a software development tool, which is more modular than the one we had before, to help us to design the hardware to do real-time speech processing. After feeding the real speech data into a second-order bandpass filter, we write our envelope-extraction codes in such a way that we can build corresponding hardware. Then we quantize the output data to get binary signals out. We would like to finish writing the codes and implementing the last channel for voiced/unvoiced



CHEMISTRY & CHEMICAL ENGINEERING

Gas Diffusion Through Polymer Membranes

Pamela A. Abshire
Sponsor: William A. Goddard III

Understanding gas diffusion through polymer membranes is an important problem with many practical applications. With recent advances in hardware and software it is now feasible to study this problem using computer simulations. As a first step for gas diffusion through polymer membranes we consider the diffusion through crystalline polymers. We start with the simplest case: a gas molecule (N_2) imbedded in a polyethylene [$(-CH_2-)_n$] matrix. Calculations were performed using BIOGRAF, a molecular dynamics software package available from Molecular Simulations Inc. of Pasadena. Initial studies suggest that the N_2 molecules incorporated into the matrix tend to align themselves parallel to the polymer chain direction; the chains also remain relatively rigid such that the gas molecules form pores through the matrix. Further extensions of this work involve expansion of the model and application to other systems. The current model allows only Van der Waals interactions between the gas molecules and the polymer matrix; a more accurate description of the interaction includes dipole and quadrupole moments, if present. Other interesting systems for application are gas molecules other than N_2 (O_2 and CO in particular), polymers other than polyethylene, and systems other than crystalline (amorphous systems and surfaces).

Turning a Synthetic Polymer Into a Catalyst by Templating

Jeannie E. Barrett
Sponsor: Robert H. Grubbs

Poly 7-oxanorborene-2,3-dicarboxylic acid was synthesized using dipotassium ruthenium pentacloride, a ring opening metathesis polymerization catalyst, and purified through dialysis. This synthetic polymer was then templated to a transition state analog of carbonate hydrolysis (p-nitrophenyl-phosphoryl choline). The templated polymer was then tested for its ability to catalyze the carbonate hydrolysis of p-nitrophenyl N-trimethylammonioethyl carbonate cloride using ultraviolet spectroscopy.

An Alternative Method to the Fourier Transform in NMR-Spectroscopy

Marni E. Bozer
Sponsor: John D. Roberts

This project was computer-intensive and involved exploring an alternative method to Fourier Transform NMR-Spectroscopy. An experimental Free-Induction Decay (FID) curve was generated using 256 data points from a digitized spectrum. An analyzing curve was then generated holding several parameters (such as concentration and T2 time) constant while the frequency was varied. The two curves were then compared and a plot was made of their frequencies versus their correlation coefficient; this procedure was repeated 256 times for a single FID to yield a graph which resembles typical plots of spectral data.

Synthesis and Study of Molecular Hosts

Aaron R. Clements
Sponsor: Dennis A. Dougherty

Model syntheses have been carried out for a general method of modifying the solubility and binding properties of an existing class of macrocyclic host molecules. Modification is accomplished by conversion of carboxylic acid groups (-COOH) to secondary amides (-CONHR, R=variable) using diimide synthesis techniques.

Nitrile Substituted Proline Analogs from *Trans*-4-Hydroxyproline

Colleen A. Costello
Sponsor: Barbara Imperiali

Functionalizing proline is important in the synthesis of hydrophillic tetrapeptides. In addition, the incorporation of proline in the n+1 position of a β-turn enhances the turns stability. Hence, the incorporation of a hydrophillic proline in a hydrophobic β-turn tetrapeptide will enhance the biological activity of an otherwise insoluble peptide chain. The methods used in attempting to synthesize a nitrile substituted proline ring are described. Although the nitrile was not obtained, intramolecular effects which may have inhibited the substitution are discussed briefly. Using the easily obtainable *trans*-4-hydroxyproline as a starting material, substitutions at the 4-position were attempted through direct S_n2 displacement of the secondary alcohol or displacement of the activated mesylalcohol with a nitrile anion. (2S,4R)-1-Benzyl-4-cyano-2-methoxycarbonylpyrrolidine was obtained and fully characterized using spectroscopic methods.

Introducing PBP-5 Activity Into RTEM-1: A Novel Chimeric Protein
David E. Coufal
Sponsor: John H. Richards

The DD-peptidases (penicillin binding proteins, or PBPs) exhibit considerable primary sequence homology with the class A β-lactamases. However, the β-lactamases have no DD-peptidase activity. A chimeric protein inserting a 6 amino acid residue segment of PBP-5 in place of the corresponding segment in RTEM-1, an E. coli β-lactamase, was designed using cassette mutagenesis. The amino acid segment is adjacent to Serine 70, the active site residue that forms the acyl-enzyme intermediate in β-lactam hydrolysis. The segment is hypothesized to be important in positioning of Serine 70 for PBP activity. The chimeric protein was expected to exhibit DD-peptidase activity. Results are not available at time of writing.

Airborne Peptides: A Preliminary Study of Peptides in the Gas Phase
Michael D. Ehlers
Sponsor: Jesse L. Beauchamp

Infrared thermal laser desorption, pulsed ultraviolet laser desorption, and vacuum sublimation were used in conjunction with Fourier Transform-Ion Cyclotron Resonance Spectroscopy (FT-ICR) in initiating the study of small ionized peptides in the gas phase. Electron beam fragmentation as well as on- and off- resonance collision induces dissociation (CID) were used to study the fragmentation patterns of diglycine derivatives in order to understand the energetics of fragmention formation. Isolation of the C-terminus acyl ion was attempted to study reactions of this ion with ketene. Acylation of the N-terminus amine group was used to increase sample volatility in an attempt to facilitate gas-phase induction through vacuum sublimation. An on-resonance CID sprectrum of N-acyl diglycine was obtained. The spectrum revealed the possibility of the C- terminus acyl ion cyclizing intramolecularly to give a very stable tertiary carbocation.

Structure Property Relationships for Second- and Third-Order Nonlinear Optical Materials
R. Bernard Grubbs
Sponsor: Seth R. Marder

A series of x-methoxy-y-nitrostilbenes (where x and y = 2,3,4) have been prepared and characterized by ^{1}H n.m.r. and UV-vis spectroscopies. Also compounds of the form R-CH=CH- 3,5-$(NO_2)_2C_6H_3$ (where R= 4-CH_3O-C_6H_4-, 4-$(CH_3)_2N$-C_6H_4- and 4-$(CH_3)_2N$-C_6H_4-CH=CH) were also prepared and characterized as above. These compounds allow one to probe the effect of substitution pattern on the magnitude of the first hyperpolarizability (β). Electric field induced second harmonic generation studies on these materials suggest that contrary to previous assertions, cross conjugated materials can give rise to significant and indeed useful optical nonlinearities.

In a separate project soluble silicon phthalocyanine complexes were synthesized and their optical limiting efficiencies measured. It was observed that the smaller silicon phthalocyanine monomer synthesized here was roughly as efficient as the previously examined silicon napthphthalocyanine, which is amongst the most efficient compounds known for optical limiting.

The Characterization and Isolation of N-Glycosyl Transferase
Tarun M. Kapoor
Sponsor: Barbara Imperiali

The ability to glycosylate the Asparagine residue of glycoproteins is inherent to all eukaryotic systems. The enzyme carrying out the transfer of the several diverse substrates in this glycosylation reaction in several biologically diverse systems, has been conserved through evolution and its ubiquitous presence exemplifies its organic significance.

Due to the relatively low lability of the yeast enzyme, it was decided to work with *Sacromyces Cerevisiae* WT. A radioactive substrate-Dol-PP-GlcNac-[^{3}H]GlcNac was used to assay for the enzyme's activity throughout the purification and characterization. A zwitterionic detergent - N,N-Dimethyldodecylamine -N-oxide, which is a 'small ampiphile', was selected for the solubilization of the membrane bound enzyme since it did not interfere with either the assay or the precipitation/purification steps. The affinity of the enzyme for Conconavalin A, a lectin with affinity for high mannose glycoproteins, not only helped characterize the enzyme as a high

mannose glycoprotein but also provided a significant purification, eliminating over 90% of the microsomal proteins. Gel filtration, after the affinity column, will enable the isolation and further characterization of the enzyme.

Gene Synthesis, Expression, and Mutant Characterization of *Pseudomonas aeruginosa* Azurin
Agnes Y-C. Lew
Sponsors: Harry B. Gray and John H. Richards

Azurin is a 128 amino acid long protein involved in bacterial electron transfer through its copper center. A gene for azurin from *Pseudomonas aeruginosa* has been synthesized using a series of overlapping oligonucleotides in five steps. Azurin has been expressed in *E. coli* using the signal sequence of *Pseudomonas* which directs the protein to the periplasmic space. Furthermore, site-saturation mutagenesis at methione 121, one of the copper ligands, have yielded all 19 other amino acid mutants, as well as the amber stop codon. Various spectroscopic techniques have been used to characterize these mutants. These results lead to a better understanding of the requirements of this unusual "blue copper" binding site.

Determination of the Rate of the Reaction $SiCl_4 + H_2O = SiO_2 + 4\ HCl$
Melissa Y. Li
Sponsor: George R. Gavalas

Liquid silicon chloride and water were injected into a constant-volume batch reactor kept at 125°C, 250°C, 450°C, and 600°C. As the reaction $SiCl_4$ (g) + H_2O (g) = SiO_2 (s) + 4 HCl (g) proceeds, three moles of gases were consumed and four moles were produced to give a net gain of one mole of gas for every mole of $SiCl_4$ reacted. The pressure of the constant-volume batch reactor was monitored to determine qualitatively the rate of reaction. It was found that the higher the temperature, the faster the reaction rate. Interestingly, the product of the reaction, silicon dioxide, took in different forms at different temperatures.

MRI Red Blood Cell Modelling Through Filled Blood-Cell Ghosts
Eugene S. Lit
Sponsor: John D. Roberts

The images generated in magnetic resonance imaging rely on the relaxation of the protons found in tissue and blood. To better understand the relaxation processes of whole blood, models of red blood cells were made by isolating blood-cell membranes (ghosts), filling them with water solutions of paramagnetic compounds, and resealing the ghost walls. Ghosts that had been filled with solutions of the paramagnetic tetrasodium meso-tetra-(4-sulfonatophenyl)-porphine dodecahydrate were shown to have similar properties as red blood cells, and are stable at room temperature for long periods of time. These ghosts can now be tested under varying conditions which simulate different physiological conditions.

Chemistry 1a Graphics
James A. Low and Andre T. Yew
Sponsor: Nathan S. Lewis

The hydrogen electron density wavefunctions are taught in Chemistry 1a. The functions are difficult to visualize because they are four dimensional plots; three for space, one for electron density. We have attempted to make some of these plots easier to understand with three dimensional computer graphics videos. The videos show three dimensional orbitals, rotated at angles so that the viewer can see the overall shape, nodes, and symmetry of each orbital. We drew the 1s, 2p, 3p, 3d, 4p, 4d and 4f orbitals. The orbitals were designed and calculated using a Hewlett-Packard 9000 series computer, and the final video graphics were rendered on a Silicon Graphics IRIS.

Large Scale Preparation and Isolation of Ruthenium Labeled Cytochrome c
Jason D. MacLeod
Sponsor: Sunney I. Chan

Using a two-step procedure developed by previous researchers, Cytochrome c was labeled at specific lysine groups with Ruthenium bis(bipyridine)dicarboxybipyridine. The resulting modified proteins were separated by FPLC.

The procedure involved the esterification of specific lysine groups of the protein. Addition of an ester-binding Ruthenium complex produced Ruthenium labeled Cytochrome c. This procedure has been reworked so that larger scale preparations of modified Cytochrome c will be possible, allowing study of electron transfer in Ruthenium/Cytochrone c complexes.

A Study of the Rotational Barrier of the NH_2 Groups of the Urea Molecule Using NMR Spectroscopy

Mary Katherine Raymond
Sponsor: John D. Roberts

Proton NMR spectra suggest that at room temperature the NH_2 groups of the urea molecule rotate rapidly about the N-C bonds on the NMR timescale. To determine the energy barrier for this rotation, proton NMR spectra were taken at temperatures down the 195 K. Singly ^{15}N-labeled urea was investigated, because the NMR peaks of the hydrogens adjacent to ^{14}N nuclei, but not the ^{15}N nuclei, are broadened by quadrupolar relaxation. However, doubly labeled ^{15}N-labeled urea gives spectra too complex for straightforward analysis. A computer program that generates spectra utilizing lineshape equations was modified and implemented to analyze the line shapes of the low-temperature ^1H NMR spectra. The singly labeled compound is of special interest for studies of this kind because, with it, one can measure the individual changes in spectra of both the ^{15}N and ^{14}N atoms.

Preparation Methods for Imaging DNA at Atomic Resolution

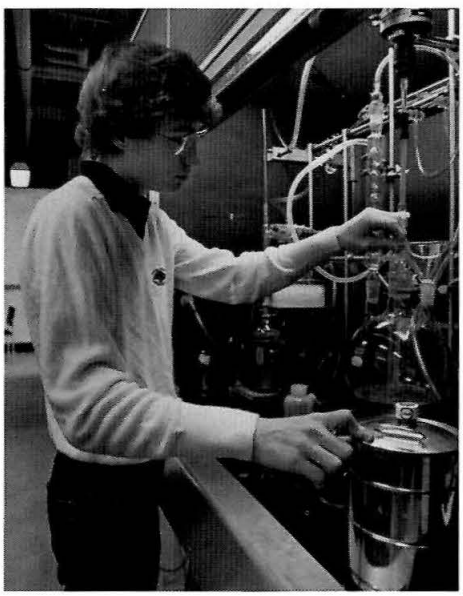
Mark A. Schmidt
Sponsor: John D. Baldeschwieler

Investigated were various methods of preparing naked A-form DNA for imaging at atomic resolution by an ultra-high vacuum scanning tunneling microscope (UHV-STM). Emphasis was on the use of electrospray ionization (ESI). An ESI apparatus was built, designed to incorporate various features facilitating quick, easily reproducible sample preparation. Multiple parameters important to implementation of ESI were investigated, with the goal of quantifying optimal values.

Hydrogen-Atom Transfer from Aromatic Alcohols to Tetrakis (μ-pyrophosphito)diplatinate(II)

Michael F. Simpson
Sponsor: Harry B. Gray

The photoreactions of tetrakis(μ-pyrophosphito)diplatinate(II) (Pt_2) with aromatic alcohols have generated



interest as a means of producing H_2 for use in fuel cells and other power producing systems. The mechanism for the oxidation of these alcohols is not fully understood, but the first step is hydrogen-atom abstraction from the hydrogen attached to the α-carbon. The Pt_2 is excited to the $d\sigma^*p\sigma$ triplet excited state via 370 nm irradiation and is deactivated via H-atom abstraction from alcohols docked with the Pt_2. This H-atom transfer has been modelled using the Michaelis-Menten kinetic scheme where the alcohol docks with the Pt_2 and then deactivates the excited state via H-atom exchange. Evidence has been found from activation parameters that both tunneling and normal thermal transfers occur here. This is critical to understanding how to better facilitate H_2 production using more abundant fuels as H-atom donors.

The Effects of Chemical and Physical Environments on the NMR Relaxation Times of Protons

S. Lan Smith
Sponsor: John D. Roberts

To observe the effects of different environments on the relaxation times of protons, T_1 relaxation times were measured in solutions of different viscosity and chemical composition. Using a 90-MHz NMR spectrometer, T_1's of the water protons in solutions of different polymers were measured at different sample temperatures to cause changes in viscosity. Several problems were encountered with this instrument, however, and the experiments became very time consuming. This project was then temporarily set aside to measure the effects of magnetic nuclei in solvents on the relaxation of solvated species containing only one magnetic nucleus. Calcium formate was chosen because, besides its one proton, it is composed of carbon-12, oxygen-16, and calcium-40, all of which are non-magnetic. Using a 500-MHz spectrometer, the T_1 of this single proton was measured in deuterium oxide and water solutions. EDTA was also added to the solutions to reduce, and hopefully to eliminate, relaxation caused by paramagnetic ion impurities in the solutions, and at the same time determine how much of the relaxation was caused by those ions.

Studying the Conformations of Succinonitrile Using Proton Continuous-Wave and Fourier-Transform NMR

Helen Yii-Ling Tsai
Sponsor: John D. Roberts

^{13}C-^1H and ^1H-^1H nuclear coupling through one bond and three bonds in succinonitrile were explored through continuous-wave ^1H NMR spectra. That such coupling occurs was verified by the presence of ^{13}C on the proton resonance of the symmetrically

placed succinonitrile symmetrical proton resonance signals in addition to the main peak reflecting noncoupled protons. Other asymmetrical resonances were associated with impurities and/or spinning side bands. Approximate relative chemical shifts and intensities were measured. Numerical integration by computer of the Bloch equations using the approximate chemical shifts, intensities, transverse and longitudinal relaxation times, and equilibrium magnetization, sweep width, and sweep time gave peaks which were summed. The resonances so detected were hoped to give information regarding conformational equilibria.

Studying the Reversibility of the Ammonium Cyanate-Urea Transformation Through Heteronuclear Fourier-Transform NMR
Helen Yii-Ling Tsai
Sponsor: John D. Roberts

The reversibility of the transformation from ammonium cyanate to urea was investigated. ^{13}C and ^{15}N spectra of a mixture of doubly and nonlabeled ureas were taken as a control. Numerical integration by computer of the known rate equations pertinent to the ammonium cyanate-urea conversion was then performed to predict the concentrations of various species present as a function of time, given values of the association and dissociation rate constants, the total reaction time, and the desired increment of time. The transformation was then carried out using the control sample at 100° Celsius and stopped after the time predicted by computer simulation necessary for the concentration of singly labeled urea to rise to equal that of doubly labeled urea. ^{13}C and ^{15}N spectra of the transformed sample indicate the following: 1) urea is in equilibrium with cyanate, 2) the conversion from urea to cyanate occurs at a somewhat faster rate than was predicted, and 3) a subsidiary transformation into carbonate occurs.

An *In Vivo* Study of Erythrocyte Ghost-Paramyxovirus Complex Distribution
Alex Wein
Sponsor: John D. Baldeschwieler

By using standard techniques in molecular biology, progress was made in the transfection of mammalian cell lines. The application of liposome technology to transfection efficiency *in vitro* and *in vivo* was explored.

Immobilized Metal Affinity for Proteins
Emily P. Wen
Sponsor: Frances H. Arnold

Sodium phosphate buffers are often used in two-phase aqueous partitioning of proteins. However, sodium phosphate solution creates an electric potential between the dextran and polyethylene glycol phases that is unfavorable for the extraction of cytochrome *c* into the top, polyethylene glycol phase. We have been investigating alternative buffers, and a promising candidate has been identified: 1 M potassium phosphate and 100 mM 30[N-morpholino]propane-sulfonic acid. In this buffer, we obtain higher partition coefficients for native and mutant *Saccharomyces cerevisiae* cytochromes *c* than using sodium phosphate buffer.

In addition, site-directed *Saccharomyces cerevisiae* cytochrome *c* mutants have been isolated and purified. We have added one or more histidines to their surfaces in order to study the metal-histidine interactions. After cell lysis, the cytochrome *c* mutants are then purified on an ion-exchange column. It is desirable to replace ion-exchange chromatography with aqueous two-phase extraction which is less expensive and less time-consuming. Conditions such as temperature, metal concentration in the polyethylene glycol phase, pH, charge, and molecular weights of the polyethylene glycol and dextran polymers are adjusted so that the extraction of cytochrome *c* mutants into the top phase is optimized.

Theoretical Studies in the Conformation and Reaction of Lithium Organocuprate Clusters
John A. Wendel
Sponsor: William A. Goddard, III

Lithium dialkylcuprates are of established importance in organic synthesis, efficiently transferring alkyl groups with retention of configuration to the β position of conjugated enones while showing almost no reactivity with nonconjugated carbonyls. However, the structure of the active reagent and the mechanism of conjugate addition remain uncertain. Using ab initio electronic wavefunctions bonding in the cluster $Cu_2Li_2Me_4$ has been investigated and compared with that in Li_4Me_4 and Cu_4Me_4. Orbital directionality of the Cu centers and agostic Li···H-C interactions are found to be important in determining the overall geometric preference of the compounds. Previously proposed mechanisms for the conjugate addition reaction have been examined in the light of our generalized valence bond representation.

Studies of Metal-Chelate/Histidine Interactions Via Protein NMR
Joanne W. Yun
Sponsor: Frances H. Arnold

The focus of this project is to use NMR resonance assignments of *Candida krusei* cytochrome *c* to study the interaction of metal-chelate complexes with the surface histidine residues in related strains of this protein. Determination of structural and/or conformational changes in the metal-bound protein will be used to exploit metal affinity separations in a variety of proteins, including synthetically engineered metalloproteins.

ENGINEERING & APPLIED SCIENCE

Automating Classroom Laboratories with LabVIEW

Joseph P. Andrieu
Sponsor: Rodney M.F. Goodman

Computerized automation is used to eliminate wasted time in the laboratory. In a classroom lab, a large amount of time is spent setting up experiments. Often the complexity of the instrumentation causes needless confusion for the lab assistant and the students, increasing procedural time unnecessarily. Using the LabVIEW programming environment, along with the Macintosh computer system and interfacing hardware, in a system of Computer Aided Instruction, not only is set-up time minimized, but overcrowding instruments are replaced by and/or put under computer control allowing real-time data analysis using the computer, saving time and money in the lab.

Transposon Mutagenesis of Methane-Oxidizing Bacteria

Marcus A. Averbach
Sponsor: Mary E. Lidstrom

Methanotrophs are bacteria that utilize methane as their primary carbon source. The first reaction in the methane oxidation pathway involves the enzyme methane mono-oxygenase, or MMO, which catalyzes the conversion of methane to methanol. This enzyme can also detoxify various halogenated compounds present in the environment. The Tn916 transposon was inserted into the chromosomal DNA of the methanotrophs. Insertions disrupt the transcription of the gene containing the transposon. If the transposon inserts into the MMO gene, a methane-oxidizing mutant arises, which would facilitate characterization and analysis of the MMO gene. This enzyme is of particular importance for study because of the potential use of methanotrophs in cleaning aquifers polluted with halogenated compounds.

Heat Capacity - Measurement of Liquid Alloys

Lee J. Burrows
Sponsor: W. L. Johnson

The heat capacity of solid and liquid Au-Ge eutectic alloy was measured. Based on the measured values for Cp, the entropy, enthalpy, and the Gibbs free energy differences were determined between the super-cooled liquid phase and the solid phase of the alloy. The experimental heat capacity values for the eutectic solid are within 2% of the theoretical values for a fractional molecular weight addition of the heat capacities for pure Au and pure Ge. This indicates that the alloy is a laminar eutectic consisting of alternating regions of Au and Ge. The alloy was made by combining 12% Ge and 88% Au by weight and then melting them in a vacuum sealed quartz tube. The heat capacity data was then obtained by using a differential scanning calorimeter. The accuracy of the machine was tested by running samples of pure Au and pure Ge and was found to be between 0.5% and 3% depending on the temperature range.

Nanophase Materials Created by Mechanical Attrition

Kenneth L. Campman
Sponsor: Brent T. Fultz

Nanophase materials are polycrystals with a crystal size of only a few nanometers. We attempted to create these materials by subjecting powders of

several binary alloy systems to high energy ball milling (a process which uses a machine similar to a paint shaker). X-ray diffractometry and Mossbauer spectroscopy were used to analyze the resulting powders. Fe-Ti and Cr80-Fe were both found to become nanophase with an average crystal size of approximately 3 nm. We propose that the crystal size after mechanical alloying is related to the heat of formation of the binary alloy.

Reflective High Energy Electron Beam Diffraction

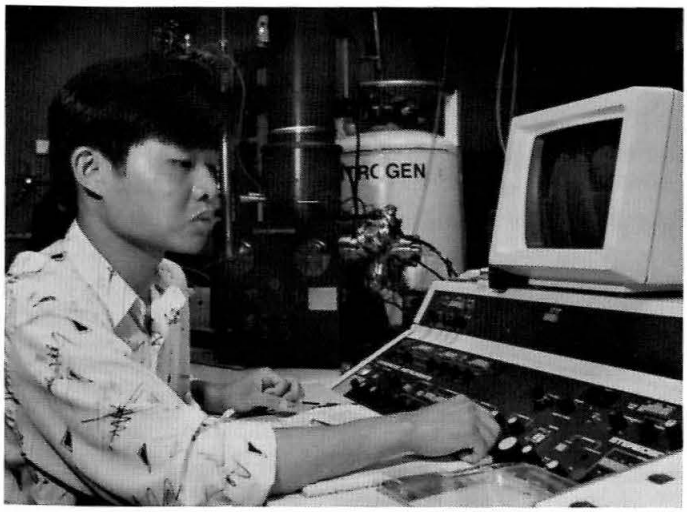
Tracy C. Fu
Sponsor: Thomas C. McGill

Reflection High-Energy Electron Diffraction (RHEED) has long been a useful tool monitoring the growth quality during Molecular Beam Epitaxy. Much of the information we get from the RHEED, however, is only qualita-

tive. My SURF project involves getting more quantitative information by digitizing the diffraction patterns and analyzing them by computer. By doing this we can get information on how the lattice is strained, lattice constant, and the growth rate, of a sample during Molecular Beam Epitaxy.

Ion Channeling Moire Lithography
Gregory D. Hale
Sponsor: Harry A. Atwater

The usefulness of a lithographic technique depends on its resolution and data rate. Masked Ion Beam Channeling Lithography (MIBL) has an extremely high data rate, but is limited to a resolution on the order of 10 mm. A scanning E-beam or focussed ion beam has a resolution of about 100 Å, but an extremely low data rate.



Ion Channeling Moire Lithography is a novel technique that combines high data rate with extremely high resolution to form periodic patterns. Two ultrathin (one to four μm) single-crystal silicon membranes are brought into intimate contact with each other and a channeling condition is set up in the first using Rutherford Backscattering. The second membrane acts as a mask, stopping any ions incident on it that are not in channeling configuration. This interference creates a flux pattern similar to an optical Moire pattern. The periodicity is directly related to the angle between the endplane lattice vectors of the two membranes, the resolution is expected to be on the order of 10 - 200 Å and the exposure time is expected to be on the order of 10 seconds. Such a periodic pattern may find use as a template for controlled crystal growth.

Fire Alarm Detection for the Hearing Impaired
Hanna S. Hsu
Sponsor: Edward C. Posner

A device is developed to convert audio signals of a regular fire alarm to signals of forms sensible to the hearing impaired, e.g. light or mechanical impulses. The project is aimed at a particular type of fire alarm which emits intermittent audio pulses at frequencies ranging from 2 kHz to 4kHz and at 60 pulses per second. The device monitors its audio environment for signals with these two characteristics and responds when they are detected.

Refreshing Multiple Holograms in Photorefractive Lithium Niobate Crystals Using Optical Feedback
Joseph B. Jensen
Sponsor: Demetri Psaltis

The usefulness of photorefractive crystals for information storage in optical systems depends on the ability to record and maintain multiple holographic gratings within the crystals. One method being explored periodically restores multiple holograms using an optical feedback loop which reconstructs and amplifies the input signal from the diffracted output. Refreshing is required to prevent previously recorded holograms from being erased by those recorded later. Experimental results also suggest that self-enhancement of holographic gratings can occur without optical feedback in lilthium niobate under certain conditions.

***In Situ* Optical Diagnostics of Diamond Growth**
Dong-Su Kim
Sponsor: David G. Goodwin

Optical methods such a Second Harmonic Generation (SHG) are very convenient in examining the growth of Chemical Vapor Deposition (CVD) diamonds because it can be done *in-situ* without disturbing the growth process. The Second Harmonic signals during different stages of CVD process on different substrates have been examined. The results can be further developed to be used in diagnostics of the growth mechanism of CVD diamond.

***In-Situ* Biodegradation of Trichloroethylene by Methanotrophs**
Betty K. Pun
Sponsor: Mary E. Lidstrom

The purpose of this SURF project is to determine the effect of varying copper concentration on the consumption of methane by *Methylomonas albus* BG-8. The Michaelis-Menten parameters including the K_m value of methane mono-oxygenase (MMO) were determined by measuring the rate of consumption of methane using a gas chromatograph. The results showed that as copper concentration increased from 5 to 20 uM, K_m values decreased, indicating an increase in the affinity for methane. This has significant implication for the *in-situ* use of methanotrophs for detoxification of underground water contaminated with halogenated organic compounds.

InGaAs/AlGaAs V-groove Quantum Well Lasers

Rajeev J. Ram

Sponsors: Amnon Yariv and Lars Eng

New technologies being developed in the field of integrated optoelectronics, e.g. computer optical interconnects, require semiconductor lasers with very low power consumption. Strained InGaAs/AlGaAs quantum well lasers are a relatively new class of structures that have the potential for low threshold currents in the one micron wavelength range. Another possible technology for low threshold lasers has been V-groove lasers. Their small inverted volumes and good lateral current confinement are both factors that can lower threshold currents. We are working on strained V-groove quantum well lasers in hopes of reaping the benefits of both of the above mentioned technologies. The preliminary work that is being conducted involves the study of different etching systems, amphoteric doping and compositional modulation in the indium grown on the V-groove substrate. Several etching systems were studied so that the sidewalls of the V-grooves could be etched in specific crystal planes on the p-type GaAs substrate. Crystal orientation dependence is then being studied of n- and p-type Si doping in molecular beam epitaxy (MBE) and thermal diffusion for current lateral confinement. Laser structures will then be grown on the V groove and threshold current, quantum efficiency and spontaneous emission spectral measurements will then be made.

Hand-Printed Character Recognition

Christopher D. Rosin

Sponsor: Alan H. Barr, Jr

A framework was developed for experimentation with hand-printed character recognition. Characters were entered on a graphics tablet, and features were extracted from them for comparison with a database of labeled samples. The focus of the project was feature selection. The initial algorithm segmented the character into straight lines, which were parameterized and used as features. Successive experiments improved the initially low recognition rate. These experiments included transformation of the character to canonical form (translation-, rotation-, and scale-invariant), fitting curves to portions of the character, and using features based on bend angle and curvature. The most successful representations were based on bend and curvature, and achieved a fairly high recognition rate.

Action Nouns in the New World of Computing: An Application of Case Grammar to a Computational Linguistic System

Erich R. Schneider

Sponsor: Frederick B. Thompson

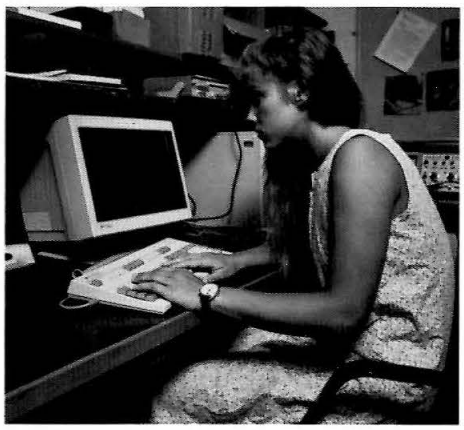
Case grammar is a branch of linguistics which studies certain transformationally invariant semantic roles in sentences. We have implemented certain ideas of case grammar in a new grammar construct for the New World of Computing natural language processing system: the action noun. The action noun is a construct analogous to the function in a computer programming language; it provides increased flexibility in interacting with pre-existing program libraries and accessing foreign data base systems.

Global Air Pollution Modeling

Jill E. Shankel

Sponsor: Glen R. Cass

In order to set up a global air monitoring network, optimal monitoring site locations and number of monitors needed must first be studied. Due to limited data on ambient air pollutant concentrations, a data base of world population density was set up and used to test a weighted interpolation model. The model finds a global



distribution pattern from a small number of known points. The population data will then be modified using energy consumption data and used to determine the monitoring sites.

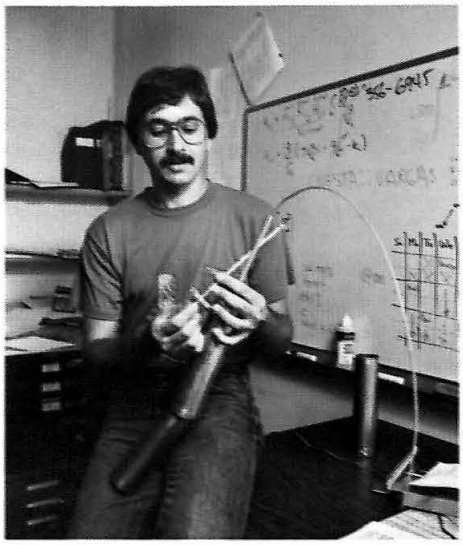
Caltech's New Spheromak Injector

Barry C. Stipe

Sponsor: Paul M. Bellan

In the past few years tokamaks have become the most successful fusion reactor design. More recently, the use of spheromak injection (a spheromak can be thought of as a self-contained ball of plasma) for current drive and refueling in tokamaks has received some attention. Professor Bellan and Mike Brown have recently shown that the use of spheromak injection on Caltech's ENCORE tokamak does indeed increase plasma density and current. The next stage of their research is to scale this process up tenfold in order to test spheromak injection on a larger tokamak. Bellan's group is building a spheromak injector much like the original but with the addition of a coaxial rail gun. My SURF time was spent designing, building, and testing a number of different diagnostic devices. These devices include magnetic probes to be placed along the axis of the rail gun for spheromak detection and an interferometer to measure the plasma density. Also, a flux loop array was used to map the magnetic field lines in the spheromak formation stage of the gun.

GEOLOGICAL & PLANETARY SCIENCES



Consolidation of Spherical Metal Powders Through Dynamic Compaction

Melinda J. Au
Sponsor: Thomas J. Ahrens

Shock wave consolidation is the densification and bonding of particles upon impact and passage of stress waves. When applied to metal powders, this compaction may yield technologically useful products. In this project, I investigated the deformation of spherical particles by shock consolidation on a half-space. Using a mechanical model to compress clay balls, the plastic deformation of spherical metal powders was simulated. The energy strain of the system for various metal powders, assuming ideal plasticity, was then examined and compared to its corresponding shock energy. A countour mapping of this energy strain will show the distribution of energy in one plane of the sphere and the ratio of shock energy over energy strain will tell how much energy is used in plastic deformation.

Testing the Concept Feasibility of the Martian Snake Project

Joseph Bach
Sponsor: Bruce C. Murray

The Soviet/French Mars '94 mission will include a new vehicle for planetary investigation, called the Aerostat. The Aerostat is an inflatable balloon designed to carry an instrumented gondola and to drag a guiderope, affectionately called "the snake", on the Martian surface. In addition to serving as a platform for various experiments, the study of the snake's dynamics can provide information about the characteristics of the Martian terrain. A prototype snake was built and instrumented with sensors to test the concept's feasibility. The prototype snake was towed by a truck fitted with a boom, and equipped to serve as a data collecting facility and a mobile repair shop. The dragging tests were performed on various types of terrains using tow speeds of 3, 6, and 9 m/s. In addition, the snake's mass fraction on ground and towing tether angles were varied to investigate their effect on the snake's dynamics.

Mars Balloon Project

Francisco G. Gomez
Sponsor: Bruce C. Murray

The purpose of this project was to test an instrumented guide rope for a French and Soviet Mars balloon called the snake over various types of terrain similar to that of the Martian surface. The snake was towed behind a vehicle over lava, sand, gravel, and small boulders in order to test the structure and some instruments inside. The information on the Martian surface was based on data from the Viking orbiters, and information regarding the expected slopes and terrain distribution was determined for providing the French engineers with figures for creating a model of the possible conditions on Mars.

A Spectroscopic Study of Apatite: Coloration, Chemical Composition and Physical Properties

Olga Koumoutsakos
Sponsor: George R. Rossman

Natural apatites have various colors that include yellow, green, brown, blue and purple, although pure synthetic apatites are colorless. Spectroscopic measurements lead to the conclusion that Rare-earth elements and manganese are the major causes of the coloration. After heating, color disappears, suggesting irradiative coloration. Surprisingly, exposure to gamma radiation proved to be ineffective in returning the color.

Tsunami Run-Up from Oceanic Impact of the Cretaceous-Tertiary Extinction Bolide

Keith L. McCormick
Sponsor: Thomas J. Ahrens

According to a theory first presented by Alvarez *et al* in 1980, the Cretaceous-Tertiary extinction was caused by the collision of a bolide with the earth. Any such impact would have had a large probability of impacting on the ocean, resulting in the formation of giant tsunamis. This project was designed to quantify the run-up from these tsunamis for a variety of impact and crater characteristics. Preliminary calculations indicate that the run-up will be in the region of 300-400 meters.

Effects of Tectonic Structure on Earth's Moment of Inertia Tensor

Adam P. Showman
Sponsor: David J. Stevenson

The Earth's tectonic plate structure causes density variations in the mantle which perturbs the Earth's moment of inertia tensor and affects the rotational properties of the Earth. In particular, the moment of inertia about the planet's rotational axis depends on the positions and orientations of the tectonic plate boundaries. To qualitatively determine the tectonic patterns associated with high moments of inertia, most of a computer program was written which simulates "pseudoEarth's" with four to ten tectonic plates. The program will be completed in upcoming weeks.

HUMANITIES & SOCIAL SCIENCES

'Salman the Scribe' in Today's England

Deepinder K. Brar
Sponsor: John A. Sutherland

By looking at contemporary Anglo-Indian fiction we can catch a glimpse of the ways in which close contact between British and Indian cultures has led to changes in each people's way of life. Delving into the Rushdie Affair has brought to light that religious fervour and philosophical literary debate alone could not account for the ferocity of the controversy in England. The root of the affair is social, and the 'affair' merely a symptom of a larger problem.

Famine and the Storage of Grain: France and Germany (1520-1819)

Timothy J. Gerk
Sponsor: Philip T. Hoffman

Based on the theoretical models and findings of D. McCloskey J. Nash, and B. Taub, this paper will reveal results gleaned from records of grain prices from seven cities (Paris, Rozoy-en-Brie, Pontoise, Chaumont, Grenade, Munich, and Leipzig) in France and Germany from 1520 to 1819. Investigations of annual price patterns, price variability, inflation, storage costs will be explained and presented graphically. Finally, interest rates will be determined for each location for twenty-five year periods. Variations from theory and relationships of distant markets will be discussed, as well as changes in grain markets, such as a real decrease in storage costs or interest rates that could explain the end of the famine cycle in France about the year 1740.

Corporate Mergers - How Effectively Have They Been Utilized by Firms?

Daniel S. Ko
Sponsors: Preston McAffee and Jeffrey A. Dubin

Many companies frequently acquire other firms or their subsidiaries in order to stabilize their net income or increase market share, at least according to firms' annual reports. Whatever the true motives behind mergers may be, their prevalence in the American business is certainly due to the belief that, in general, they benefit their users. The assessment of this motion is the purpose of this project. While most of previous methods focus on the effects of *individual* mergers on the involved firms, this particular study emphasizes the long-term relationship between a group of mergers of a certain firm and its performance. The quantifications of these two variables are the number of mergers during 1981–1989 and the change in net income and sales between 1981 and 1989. Furthermore, in order to avoid the effects of different economic conditions dominating different industries, the firms are categorized according to their industries, and these categories are studied separately.

A Study of the Contrasts in the Development of General Relativity and Other Areas of Theoretical Physics

S. Ali Mortazavi
Sponsor: Diana L. Barkan

From its origin in 1915 to its maturation in 1975, general relativity has evolved and progressed in a significantly different fashion from the rest of physics. Throughout the initial period of great activity (1916-1930), the ensuing period of *apparent* inactiveness (1930-1959), and the final "rebirth" of the field (1960-1975), general relativity has relied more heavily on sound theory developed without acceptable experimental and observational evidence [by the standards of the physics community] than many physicists are willing to admit.

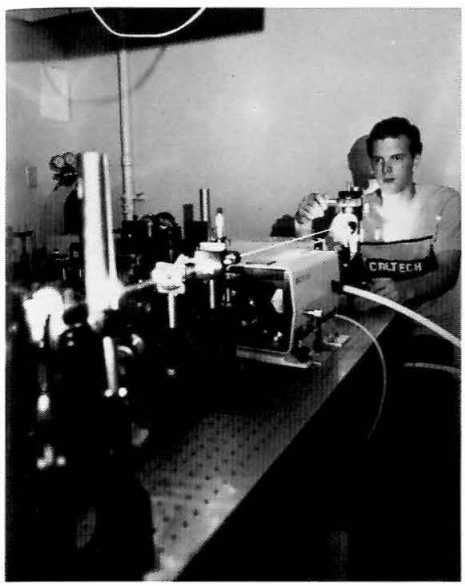
Social Mobility: A Ladder of Success in Rural Liaoning
Chris J. Myers
Sponsor: James Z. Lee

Traditionally, the Chinese had two conflicting beliefs about social mobility. On the one hand, they followed a rigid system of inheritance where local authority was determined by lineage, birth order, and age. On the other hand, they were also part of a national society where the elite continuously turned over through an examination system. As a result, they shared two contradictory social myths. First, they accepted the role of predestination and fate—that much social mobility was out of their control. Second, they also believed they could rise through ability and hard work. This paper, based on a study of some 12,000 peasants who lived in Liaoning between 1774 and 1873, attempts to study social mobility in one peasant community. Our purpose is to identify the demographic patterns characteristic of the kin and occupational hierarchy and measure the degree to which people indeed rose in these hierarchies through ability versus inheritance.

Homicide: A Ten-Year Epidemiological Analysis of Victim-Offender Relationships
Bih-Guang (Patty) Tsai
Sponsors: Louis L. Wilde and Reneau Kennedy

A longitudinal epidemiological investigation of homicide was conducted in Massachusetts and was compared to the United States using the FBI Supplemental Homicide Report (1979-1988) data. Focus of the study was upon victim-offender relationships in which strangers, acquaintances, blood kin, and affinial groupings were classified and analyzed using frequency distribution and chi-square statistics. Significant differences within classifications and between groups were found, and these outcomes were discussed in context of current theoretical hypotheses.

PHYSICS, MATHMATICS & ASTRONOMY



The Cepheid Distance Scale: Infrared Photometry and the Hubble Constant
Rebecca A. Bernstein
Sponsor: Barry F. Madore

The accuracy with which the Hubble constant can be determined is limited by the accuracy of the extragalactic distance scale, which is only as good as the weakest link in the chain of distance indicators. My project has involved the redetermination of the Cepheid distance scale – the link to the calibration of the entire extragalactic distance scale. We used a main-sequence fitting for four clusters (NGC 7790, NGC 6664, NGC 129, and M25) containing six Cepheid to more accurately establish the Cepheid period-luminocity and period-luminocity-color relations, which are used to determine distances with Cepheid variables. The data were collected at the Palomar 60 inch telescope using BVRI and UBV CCD photometry.

Relationships Between Coronal Holes, New Active Regions and Erupting Filaments
Rajesh Bilimoria
Sponsor: Sara F. Martin

The purpose of this study was to investigate the relationships between and behavior of coronal holes, new active regions, and erupting filaments on the sun. By analyzing hydrogen alpha and helium 10830 Å images of the full disk from June 1987 to May 1989, the following conclusions have been made thus far:

1) As the solar Cycle approaches maximum, the percentage of filaments that erupt declines significantly,
2) In some cases, the birth of some coronal holes is directly attributable to the eruption of filaments and
3) The hypothesis that the birth of a new active region near a filament can lead to its eruption has been confirmed in several cases.

Looking for B-mesons at the Asymmetric Beauty Factory
Brett D. Bochner
Sponsor: Alan J. Weinstein

The construction of a new electron-positron collider is being planned at the SLAC facility at Stanford, for operation in the mid-1990's: It is called the Asymmetric Beauty Factory. Running at the upsilon (4s) resonance, it will be a copious source of that massive and fascinating hadron, the B-meson. My task in this SURF project has been to design, write, and test a program dedicated to the purpose of reconstructing the quickly decaying B-mesons from detector information about their relatively stable decay products.

A Lagrange Method Solution of the Time-Dependent Schrodinger Equation
Matthew A. Class
Sponsor: Steven E. Koonin

The standard method of numerically integrating the time-dependent Schroedinger equation is an Eulerian scheme, where the gridpoints are fixed in space. A common method of numerical integration in hydrodynamics is a Lagrangean scheme, in which the gridpoints are fixed on the fluid being considered. We implement a Lagrangean scheme for integrating the Schroedinger equation in one dimension, and test the method against a variety of analytically solvable cases, such as a spreading Gaussian and a Gaussian in a parabolic potential.

An Investigation of the Response Function of a Solid State Detector
Jeremy N. Gollub
Sponsor: Charles A. Barnes

We prepared an experiment to determine the response function of an implanted solid-state detector to low energy alpha particles and carbon nuclei. To focus on particles of known energy and direction, monoenergetic alpha particles are scattered from a thin (5 mg/cm^2) carbon foil, and a coincidence is demanded between two detectors – one for the scattered alpha particles, the other for the recoiling carbon nuclei. Several Monte Carlo simulations have been carried out to aid in understanding the various factors contributing to the measured pulse-height spectra.

Minimal Manifold of Elliptical Galaxies

Varoujan Gorjian
Sponsor: S. George Djorgovski

Among the oldest objects in the universe are elliptical galaxies, which contain the largest fraction of known luminous mass. Their current properties were largely determined during the epoch of galaxy formation and so they are "living fossils" of that era. From systematic studies of their global properties one can obtain information about the physical processes that were operating during the period of galaxy formation. Moreover, one can obtain distance indicator relations which can be used to map large scale density and velocity fields. The above can be accomplished by determining the primary parameters which describe the family of elliptical galaxies. To find these variables it is necessary to have a large and homogeneous database. My SURF consisted of taking CCD pictures of galaxies and taking out instrumental signature and perturbations, like bright foreground stars and cosmic ray traces. Next, using customized imaging software, attributes such as luminosity, radius, velocity dispersion, etc., were extracted from the suitable data and formed into a catalog. This catalog will be used in an analysis with multivariate statistical techniques to obtain scaling relations between quantities of interest.

Near-Infrared Color Mapping of Arp 220

Catherine I. Hafer
Sponsor: B. Thomas Soifer

Near-infrared images and photometric data of the galaxy Arp 220 at wavelengths 1.2 μm (J), 1.65 μm (H), and 2.2 μm (K) are presented. Contour maps of the ratios of flux at J to flux at H, flux at H to flux at K, and flux at J to flux at K indicate that the two nuclei of Arp 220 discovered by Graham *et al.* (1989) have different near-infrared colors. Color maps, accompanying radial profiles, and synthetic aperture photometry show that both nuclei are much redder than the nuclei of normal spiral galaxies. The map of the ratio of flux at J to flux at K indicates evidence of dust extinction that corresponds spatially to the dust lane observed at visible wavelengths.

The Test of Cesium Iodiode Crystal as an Efficient Scintillating Material

Zhirong Huang
Sponsor: David G. Hitlin and Gerald Eigen

We have measured the energy resolution of cesium iodiode crystals, which are going to be used as scintillators in the B-meson factory. The measurements are obtained by using sodium (Na 22) radiation source with 511 kev and 1275 kev high energy photons. The energy resolution is 7.5% at 511 kev and 4.0% at 1275 kev. The homogeneity tests on four crystals of different geometric shapes show that, excluding the edges, all the crystals are very uniform for the energy resolution. The study on the collection of scintillating light optimizes the light received from the crystals and meets the requirement of detector environment.

Optical Diagnostics on Plasma

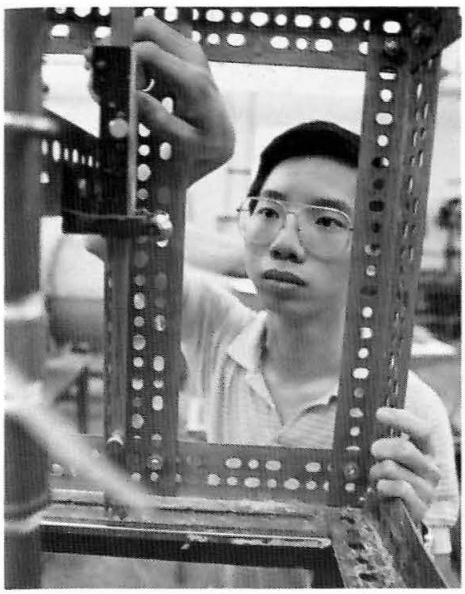
Jinha Kim
Sponsor: Paul M. Bellan

The main objective of this SURF project is to find and test a new way to do simple optical diagnostics on steady-state compact plasma devices. A detector consisting of an array of small parabolic mirrors, phototransistors and an amplifying circuit has been built to investigate the structure and the dynamics of the plasma inside such devices as the tokamak and M=1 machine. Also, we are going to probe the possibility of using the detector for tomographic reconstruction of the plasma inside the tokamak under a simplifying assumption of the existence of a steady poloidal drift wave.

Atomic Light Traps Using Spontaneous Forces

Robert B. Lee
Sponsor: H. Jeff Kimble

Confinement and cooling of a dense cloud of neutral cesium atoms



were achieved by near-resonant radiation pressure of three pairs of counter-propagating laser beams along orthogonal axes that have opposed circular polarization, and by a weak magnetic field gradient. The characteristics of the trapped atoms were studied through the use of a scanning probe beam by observing its absorption spectra. The trap was less than 1 mm in diameter and the trapped atoms are approximated to be at a temperature of less than one millikelvin.

A study was also made of frequency stabilization and locking of diode lasers by optical feedback using a grating. A diode laser is used for optical pumping in the trapping experiment.

An Investigation Into a New Method for Finding Combinatorial Relationships
Russell A. Manning
Sponsor: Richard M. Wilson

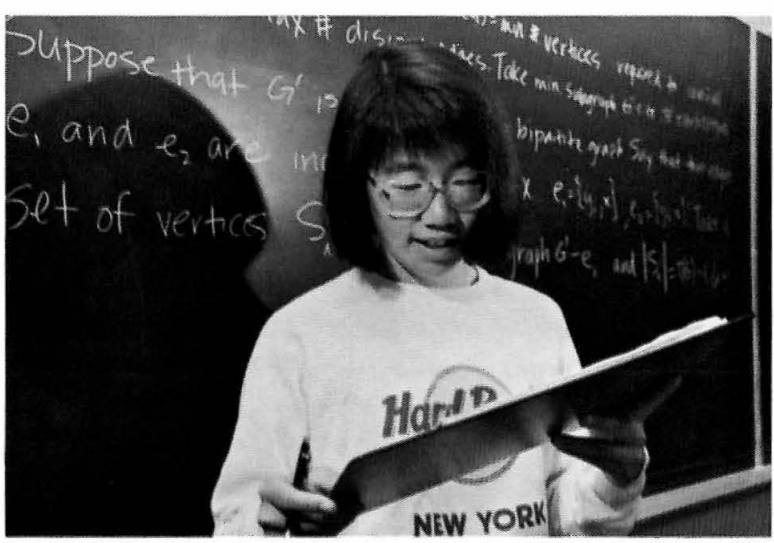
There are many examples in combinatorics of sets of constructable objects whose order is a fraction of the order of some larger set of more easily counted but similarly constructed objects. For instance, the n^{th} Catalan number is a fraction of the binomial coefficient "2n choose n". In many cases these objects can be constructed "recursively" by combining smaller objects of the same type. I am investigating such objects, possible mappings between sets of these objects and certain more easily counted supersets, and what influence the "recursive" construction has on these mappings and on the character of the objects themselves.

Convex Analysis in Finite Dimensional Spaces
Mike G. Maxwell
Sponsor: W.A.J. Luxemburg and Charalambos D. Aliprantis

A convex set is a set with the special property that given any two points in the set, the line segment joining them lies entirely within the set. Common examples of convex sets are circles, boxes, and peas. Dealing mainly in finite dimensional spaces, we studied various properties and characterizations of convex sets, with emphasis on separating hyperplanes and internal points. We also discussed convex functions and the properties they possess, where a convex function is a function such that the region above its graph is a convex set. Using the material we had accumulated, we then discussed the notions of duality and dual spaces. In particular, we used separating hyperplanes to derive Fenchel's result and dual cones to prove Farkas' theorem.

Simulation of the τ Lepton Pair Production and Decay in e^+e^- Annihilations
Christopher J. Pollett
Sponsor: Ryszard Stroynowski

CLEO II is a new particle detector system for the positron-electron collider CESR at Cornell. It is an improvement over earlier detectors in that it should provide more accurate imformation on properties of the τ lepton. Analysis of the data collected by CLEO II is going on here at Caltech as well as at Cornell. Currently, most of this analysis is being done on relatively slow Vax computers. The purpose of this SURF was to port CLEO II software over to faster Apollo computers as well as to use the existing Vax software to analyse some of the features of the data already collected by CLEO II. These features include charged track multiplicity and, with the help of Monte Carlo simulations, the probabilities of various τ decay modes.



The Design and Construction of a New Secondary Electron Device in the Time-of-Flight Heavy Ion Rutherford Backscattering Spectroscopy Detector
Pongskorn Saipetch
Sponsor: Thomas A. Tombrello, Jr.

A device that generates secondary electrons and timing signals was built. The design took the advantage of isochronous transport time of low energy electrons in a constant magnetic field to reduce the time uncertainty in the Time-of-Flight (TOF) measurement. This device will be used to determine the elemental composition and thickness of thin-layered semiconductor material. The necessary information will be obtained with the TOF measurement in the Heavy Ion Rutherford Backscattering Spectroscopy (HIRBS).

A Digital Approach to Data Analysis from a Phoswich Gamma Ray Detector[1]
Aimee L. Smith
Sponsor: John M. Grunsfeld

This paper describes a digital approach to analysis of data from a phoswich gamma-ray detector[1]. The goal is to discriminate between photons that interact with the NaI crystal, the CsI crystal, or both crystals over a wide energy range. A circuit has been designed to take the logarithm of the detector signal by means of a logarithmic amplifier circuit, digitize the signal by means of an eight-bit Flash ADC, and discriminate between the desired data (NaI events) and the background noise (CsI events) by means of computer based algorithms. This approach promises to be more precise than an analysis done with traditional analog circuitry. Data analysis and results are presented in the paper.

[1]J.A.M. Bleeker and J.M. Overtoom, Nucl. Instr. and Meth. 167 (1979) 505-513

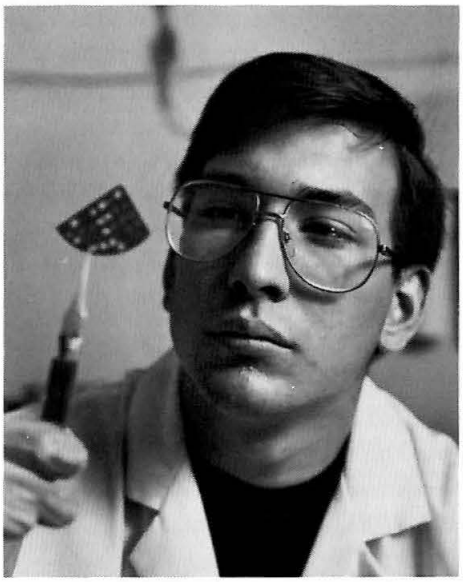
The Fekete Points of the 2-Sphere
Jun Teng
Sponsor: Thomas H. Wolff

A system of points $z_1, z_2, ..., z_n$ on the 2-sphere which maxizes $\prod_{i \neq j} |z_i - z_j|$ is called a system of Fekete points of the 2-sphere. My project is to study the distribution of the Fekete points of the 2-sphere, especially, how well they are separated and how evenly they are distributed. Towards this goal, I proved the Poincare inequality in a compact manifold.

Polarimeter Optical Components
James H. Werner
Sponsor: Marshall H. Cohen

The effective operating range of a polarimeter to be installed at the 200 inch telescope at Palomar Observatory was studied. The acceptable incident angle range was discovered as well as finding the range of wavelengths where the polarimeter is most effective. The polarimeter works well between 4000-11,000 Angstroms. The limiting factor on incident angle range was a Glan-Taylor beam splitting prism, which went bad at an angle of +1 degree horizontal incidence.

JET PROPULSION LABORATORY



MicroMITES

Imran Aziz
Sponsor: Robert C. Clauss and Edward C. Posner

The MicroMITE is an experimental satellite, the purpose of which is the comparison of the Ka-Band frequency with X-Band for deep space communication. The X-Band transmitter subsection of the satellite generates an unmodulated signal at a frequency of 8.45 GHz. The transmitter operates in two modes, the high power mode produces a 1 milliwatt signal and the low power mode generates a signal of 1 microwatt. The X-Band transmitter provides a stable reference signal against which the Ka-Band frequency signal will be tested and the reference signal will also be used to determine the position and orientation of the satellite.

Interactive Mapping of Air, Sea, and Land Data

E. Denise Breeden
Sponsor: James E. Knighton

When scientists have satellite data of a specific type expressed in latitude and longitude coordinates, they often cannot tell where the data is located on the globe. By viewing it in a certain projection, the scientists can tell more about its location and how its location relates to other data of the same value. This project combined some existing routines that performed the mathematical conversions for each projection with menus and windows on the Macintosh to create a data analysis tool that allows the user to view specific data in several different projections.

MicroMITES Structural Materials

Stephanie E. Buck
Sponsor: Robert C. Clauss and Edward C. Posner

The materials used for both the support structure and for the electronics mounting plate of the MicroMITE satellite must meet many requirements. These materials need to be lightweight and easily workable, have high stiffness and strength, have good thermal conductivity, and be fairly inexpensive. They also need to have little or no moisture absorption and subsequent outgassing, be corrosion resistant, and be relatively radiation resistant, since the satellite will be in a high altitude orbit. With all of these factors taken into consideration, the material to be used for the support structure is 6061-T6 aluminum alloy, and for the central plate, a graphite/aluminum composite.

Observing Asteroids with a CCD Camera

George J. Busenberg
Sponsor: Alan W. Harris

The purpose of this project was to establish a working technique for using a CCD camera to obtain photometric asteroid observations. Replacing a standard photometer with a CCD camera allows fainter objects to be observed and also makes automated observations possible. Working with the 240-inch telescope at Table Mountain Observatory, we successfully observed four asteroids (1951 Lick, 1990 OA, 1990 OS, and 1990 KA) using the CCD. We also performed a limited amount of data reduction. The automation of the 24-inch telescope is expected to substantially increase the efficiency of the CCD asteroid program for next summer.

Analysis of Jupiter Images at 17.8 and 18 Microns

Chris J. Campo
Sponsor: Glenn S. Orton

Images of Jupiter at 17.8 and 18 microns (infrared) were obtained at NASA's Infrared Telescope Facility (IRTF) on Mauna Kea in Hawaii for the years 1984 through 1990. The images were processed and reduced in order to determine the latidude and longitude of the point on the planet from where infrared emission was originating, and the angle from the local normal that the radiation is being emitted was also determined. The end result of the processing for each image was a latitude-longitude cylindrical projection map. The maps obtained were analyzed for time dependent trends, and a strong variation of latidudinal temperature structure with time was clearly present.

Proof-of-Concept for Hubble Extra Solar Planet Interferometer: Active Fringe Tracker Prototype

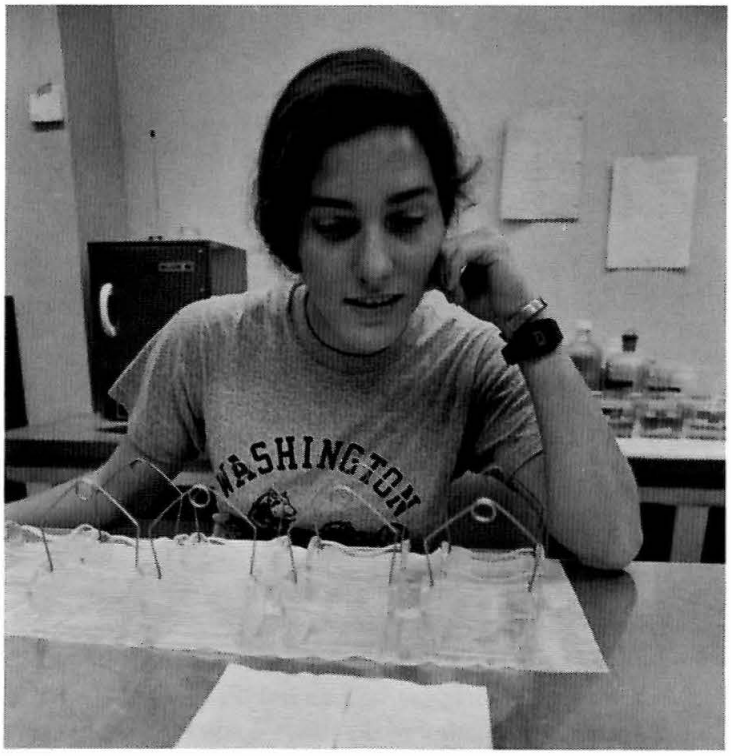
Robert K. Chang
Sponsor: Michael Shao

For SURF 1990 I designed and built a prototype active fringe tracker used in experiments proving the concept to be used in HESPI. The function of the fringe tracker is to maintain, through modulation of a piezoelectric transducer (PZT), the proper optical pathlength in the interferometer such that a minimum always occurs at the detector regardless of disturbances. Features include eight channels for monitoring eight different detectors while producing modulation signals to drive the PZT. The circuit is also fully readable and programmable by a computer through the VMEBus,

providing choice of one of eight clock speeds, and the ability to step through any given motion for the PZT, including a pre-warped driving signal to compensate for non-linearity in PZT movement.

Ka-Band Transponder
Mary Chen
Sponsor: Robert C. Clauss and Edward C. Posner

MicroMITES is planned for use to calibrate and test large antennas used by NASA/JPL Deep Space Network, especially the DSN's new research antenna at Goldstone, DSS-13. The



goal of building this Ka-band transponder is to provide an instrument that is capable of detecting the gravitational wave. Moreover, the transponder will enable us to measure more accurate doppler shifts than the on-board X-band and Ka-band transmitters will. As a result, it will improve the satellite's navigation accuracy by 10(6).

Preliminary Mission Planning for MicroMITES (Pre-launch Phases)
Jonathan K. Chow
ponsor: Robert C. Clauss and Edward C. Posner

Preliminary mission planning for the Microwave Microwatt Interferometry and Telemetry Experimental Satellite (MicroMITES) involves providing a provisional, concise summary of constraints, requirements and goals for the design, engineering and execution of the MicroMITES mission. We completed the preliminary planning for all phases of the project preceding the launch in the Spring of 1992. This involved defining the present understanding of all aspects of the MicroMITES mission and documenting the results of top-level system trade-offs and analyses performed by various members of the MicroMITES team.

It also involved performing a thermal analysis of the current spacecraft design and the creation of a flight qualification test plan for use before the launch. Using a 16-node analytical model, the current design was found to be a good thermal radiator under various conditions of solar incidence, allowing a maximum steady-state interior temperature of 40° Celsius. The test plan will provide a concise summary of the tests required, their parameters and their accept-reject criteria.

The primary end-product of this SURF will be the Mission Specification Document (Preliminary). This document will include all of the above as well as a description of the reference mission profile, science experiment requirements, and end-to-end information system.

Thermal Modelling of Comet Kopff
Celia O. Clause
Sponsor: Paul R. Weissman

A thermal model of periodic comet Kopff has been developed to aid in planning for the Comet Rendezvous Asteroid Flyby mission. The model is based on the comet nucleus model of Weissman and Kieffer (*ICARUS 47*, 302, 1981), which estimates the surface temperature distribution and sublimation rates on a rotating icy sphere in heliocentric orbit. Comparing the model results with the observed gas production rates from Kopff in 1983, and assuming a nucleus radius of 4 km, it is found that ~15% of the sunlit nucleus surface is active, a relatively high fraction for a typical short-period comet. This suggests that the actual nucleus radius may be larger than the model value. The slope of the observed gas production curve with heliocentric distance is steeper than that predicted by the thermal model. This may indicate the existence of a more complex process than direct sublimation of surface ices. It was found that for higher degrees of obliquity, the comet's water production increased significantly. Assuming a pole with low obliquity, the pre- and post-perihelion sublimation rates are remarkably symmetric. However, for higher obliquity the pre-perihelion rates are up to two magnitudes high, suggesting that observed asymmetries are perhaps due to nucleus obliquity of Comet Kopff.

Estimates of subsurface temperatures of Kopff are of particular interest to the Penetrator experiment which will deliver an instrumented package to the nucleus surface approximately one year

after arrival, at a heliocentric distance of 4.0 AU. If one assumes a low obliquity for the nucleus, the thermal model results indicate that there will likely be a broad range of 20 to 30 degrees in latitude near the nucleus rotation poles, which meets the Penetrator requirements of temperatures less than 120° K. For higher obliquity there will be a narrower range which meets Penetrator requirements. In addition, the diurnal thermal wave is not expected to penetrate more than 10 to 30 cm into the surface, assuming the modest thermal inertias used in the model. The estimated gas production rate at 4.0 AU is ~$10^{24} s^{-1}$.

The Development of Metal Blacks for Particle Dust Capture

Suzan G. Davidson
Sponsor: Gregory H. Bearman

Metal blacks were fabricated and tested as substrates to capture 1 - 15 μm size comet dust particles for analysis by electron microscopy by SEMPA, a flight instrument.

Gold and copper blacks were formed by evaporating metals at 200 mTorr of argon. The smoke from the metal landed evenly on silicon substrates, forming tree-like columns, 2 to 30 μm thick.

Each black's capture efficiency was tested by exposing it to 50 - 200 m/s dust particles in a dust gun; particle capture efficiency was determined visually with an SEM. The particles need to be in view for SEM imaging and x-ray analysis.

Cost/Benefit Relationships in Engineering Models

Craig Eckstein and David Huang
Sponsor: William Whitney

The problem addressed was the costs and associated benefits of including an engineering model in the instrument development process. First, a qualitative analysis was performed to obtain empirical arguments for and against the use of engineering models. Next, two case studies were performed, one on the Microwave Limb Sounder (MLS) power supply and one on the MLS radiometer. These case studies were used to provide a quantitative data to support our qualitative analysis. In both of these cases it was determined that it was cost-effective to build an engineering model. In addition many other, non-financial benefits were provided by the engineering model.

After analyzing the results of this study, we found strong support for the inclusion of engineering models as part of the instrument development process and we believe that an engineering model should be assumed as part of all future projects. We believe that additional study is needed on this subject and we have included a proposal for a follow-up study as part of this report.

A Neurobioligically Feasible Object-Oriented Computational Vision System

Aaron T. Emigh
Sponsor: Teri Lawton

This project attempts to implement a computational vision system that, at its lower levels, reasonably models what is known of the human vision system. From these levels, at which oriented sine and cosine filters provide edge detection, it builds an object oriented analysis of natural scenes. Given a series of such scenes from a moving vehicle, it contructs depth maps based on the motion parallax of the objects it can match from one scene to another. The earlier stages of the program work satisfactorily, but the object maps have proven insufficiently robust for matching objects from one scene to another.

Analysis of Infrared Maps of Venus

Nhut Trung Ha
Sponsor: Glenn S. Orton

The main emphasis of this SURF was to determine and analyze infrared maps of Venus taken from the NASA

Infrared Telescope Facility in Hawaii. The data taken on February 8, 10, 11, and 12 of 1990 (simultaneously with the Galileo encounter) were reduced through a series of programs to calibrate absolute intensities, and to assign accurate geometric control to the data. Among the four mornings of observation analyzed, only one yielded reliable values of spectral intensity, and it was adopted as the standard for the other dates of observation. Images from the different mornings were compared to each other to search for repeatable rotating features, and they were compared with Pioneer Venus data at similar wavelengths and with models for the dependence of intensity with emission angle.

Simulation of Parallel Computer Architectures
Ronald C. Holdsworth
Sponsor: Leon Alkalaj

A shared memory multiprocessor architecture was modeled with the EXTEND simulator on a Macintosh computer. Strengths and weaknesses of the simulator were identified as the model was developed. Bus arbitration, shared memory, and the Motorola MC88100 RISC processor instruction set were included in the model. Measurements of performance for configurations of 1, 2, 4, and 8 processors were obtained.

MicroMITES Ka-Band Transmitter
Zulfiqar Khan
Sponsor: Robert C. Clauss and Edward C. Posner

The object of MicroMITES is to compare and calibrate the new Ka-Band communication and navigation channel with the extensively used X-Band channel. The transmitters designed transmit at both a high and at a low power level to simulate an earth orbiting satellite and a deep space vehicle respectively. There will be two copies of the satellite as such two different schemes for the Ka-Band transmitter at 32 GHz have been designed. Various schemes are considered and evaluated, the trade-offs being power consumption, weight, volume, and cost. Finally two are chosen, one uses a Dielectric Resonator Oscillator (DRO) phase locked to a crystal oscillator and a varactor multiplier. The other scheme uses a Ruby Dielectric Ring Resonator, oscillator, an amplifier, a filter also made with Ruby and phase adjuster. (This is the first such oscillator of this kind in this frequency range and as such will require further testing). Both schemes will use a PIN Diode as a switch with couplers to achieve the two power states. Most of the parts have already been ordered or made at JPL.

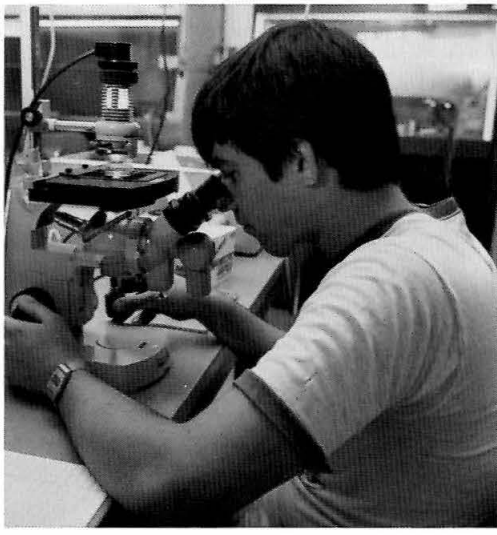
Laser Metrology for Ground- or Space-based Spatial Interfereometry
Tod E. Kurt
Sponsor: Michael Shao

The next generation of optical interferometers will require extremely accurate laser metrology systems with excellent long-term stability. For an accurate measurement, the laser beam must be kept at a constant frequency to allow the beat patterns to stay constant over time. Thus a laserlight frequency measurement device is needed to track the laser's frequency and perhaps adjust for it. The precision optics in this device must be held at a constant temperature to prevent thermal expansion and a subsequent loss of precision. This SURF was devoted to constructing a temperature control servo unit to stabilize the laserlight frequency sensor's temperature to 0.001° Kelvin.

Even though the complete thermal stabilizing unit was not fully constructed due to time delays, analysis of the circuit and isolated elements of the unit predicts a stability of 0.003° Kelvin with perhaps even better stability with more accurate calibration between the circuit's separate units.

Comparison of Simulated Oceanographic Winds
Mark T. Lakata
Sponsor: David Halpern

Knowledge of surface ocean winds, the principal driving force of ocean currents, is invaluable to the oceanographer. Two global circulation models, the European Centre for Medium-range



Weather Forecasts (ECMWF) global analysis and the UCLA model, run different simulations of ocean winds. The outputs for the last few years of both of these models were compared both quantitatively and qualitatively to gain a further knowledge of the mechanisms of the simulations, and hence a further knowledge of ocean winds. Results show the climatological magnitudes of the ECMWF model are generally 40% greater than that of the UCLA model, and the spacial structures of the models seem to differ meridonally.

Study of Laser Diode Pumping Schemes
Anita K.Y. Lee
Sponsor: James R. Lesh

Various methods of pumping a Nd:YAG rod are explored to find the optimal method which will yield 2W cw

output power at 532 μm. End-pumping and side-pumping using a 1 cm x 1 micron 10W laser diode are analyzed numerically and analytically if possible. Results may be used to design a laser diode pumped Nd:YAG laser.

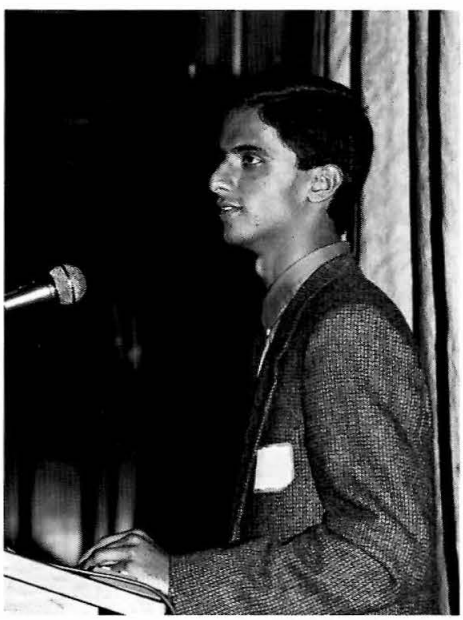
Electrical Subsystem of the Mariner Mark II
Kyung W. Lee
Sponsor: John W. Klein

Mariner is one of many satellites to be assembled and launched by JPL. The main task of this research involves a microprocessor controlled spacecraft power subsystem. Two hundred fifty-six solid state switches in the Mariner are to be controlled by National Semiconductor's 32016. Through the use of a PC, the majority of this project was devoted to testing the simulation set up and developing various computer codes, specifically in Assembly and C, to examine various features and capabilities of the microprocessor system.

Four simulation switches with dummy loads are now fully controlled by the already assembled microprocessor development board, and all the input/output functions and signal characteristics are examined and documented. Also, some modifications were made to the existing computer codes to implement and test various features of the system with a PC to monitor the whole process. Finally, some codes were developed and tested in order to simulate and illustrate the kind of environment that this microprocessor system has to function according to certain specifications.

Power Distribution System Design and Analysis for MicroMITES
Robert Liu
Sponsor: Robert C. Clauss and Edward C. Posner

MicroMITES (Microwatt Microwave Interferometry and Telemetry Experiment Satellite) is an ongoing SURF satellite project in its fourth year of development, with plans to launch for early 1992. This summer, it has been determined that the satellite's needs will be met best if each of its subsystem components draws power separately from discrete solar cell divisions. Additional research was done on solar cell characteristics and regulation options. Efficiency and simplicity requirements will be the primary considerations as a finalized scheme is developed and tested.



Phase Functions for Several Jovian Zones and Belts Derived from Voyager Imagery
David P. Max
Sponsor: Kevin H. Baines

Phase functions for five Jovian Zone/Belt regions are reported for violet, blue, green and orange Voyager 1 filters. For each region and color, phase functions are derived from five phase angle images between 7 and 142 degrees phase. In each image, several hundred points, spanning both latitude and longitude within a particular region, are utilized to determine the mean regional center-to-limb profile. Preliminary analysis indicates that the Tomasko *et al.* (1978; *ICARUS* 558-592) Pioneer-derived STrZ and SEB red phase functions fit the various orange-filter zone and belt data well, indicating (1) little regional variability from zone-to-zone and belt-to-belt, and (2) little temporal variability in the size and shape of typical STrZ and SEB aerosol particles from 1973 to 1979. The orange single-scattering albedo varies somewhat significantly from region to region, from 0.995 for the South Tropical Zone to 0.988 for the North Equatorial Belt, somewhat greater than the Zone/Belt variation reported by Pioneer, thus indicating significant temporal/spatial variability in aerosol color.

PCAS and Mars Trojans
Jonah N. Michaud
Sponsor: Eleanor Helin

The purpose of this project was both to function as a member of the Planet-Crossing Asteroid Survey team at Palomar Observatory and to perform an extra search specifically for Mars Trojans in the L5 Lagrangian point of the Mars-Sun gravitational field. Since the ten-week period began, 44 new asteroids have been discovered, including two Apollos, 1990MF and 1990OS, one Amor, 1990OA, and one Mars-crossing asteroid. However, it appears that the extra fields taken do not contain any Trojans, although the orbits from the latest set have not all been calculated yet.

Femtosecond Autocorrelator for Evaluating Multi-Gigabit/Second Coherent Fiber Optic Networks
John M. Morookian
Sponsor: Larry A. Bergman

An autocorrelator is designed which has a time resolution of 0.666 femtoseconds for measuring ultrashort pulses produced for use in a high-speed coherent fiber optic network. The longest pulsewidth that can be measured (the time window) is approximately 167 picoseconds. In addition, concepts key

to the autocorrelation implementation (such as Second Harmonic Generation (SHG), photomultiplier detection, lock-in amplifier operation, laser diode pulsing and collimation, and GPIB data acquisition) are tested in the laboratory. Finally, methods are considered which yield a cross-correlator which is able to provide information about actual pulse shape rather than just Full-Width at Half-Maximum (FWHM) data.

MicroMITES
Jimmy K. Ng
Sponsor: Robert C. Clauss and Edward C. Posner

MicroMITES is a project in which SURF students design, and build a satellite that will transmit signals at both X-band and Ka-band. As one of the two mission planners, I am responsible for making arrangements with Deep Space Network for the tracking of our satellite as well as writing part of the mission plan

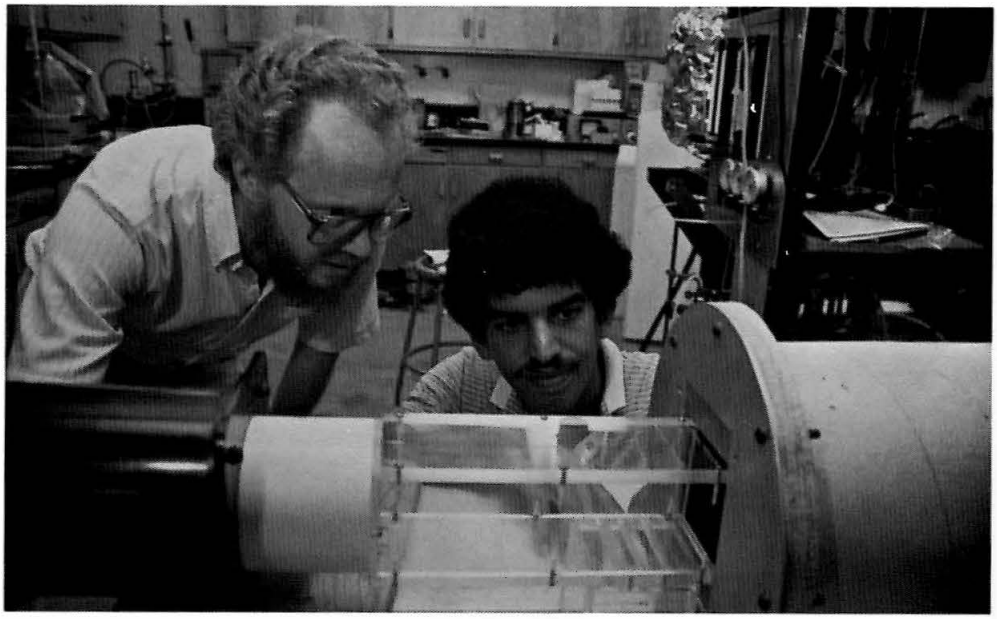
Integrated Optical Communication Test Bench
Tuan D. Nguyen
Sponsor: James Lesh

IOCTB is part of a transceiver package being studied and built for future deep-space optical communication. One of the IOCTB's main functions is to establish and maintain a reliable communication link. This task requires accurate acquisition and tracking of the sun-illuminated Earth.

The main goal of this summer project is to continue building the control electronics and develop a tracking algorithm for an experimental system to acquire and track a point source target in the far field in presence of simulated target vibrations. Evaluations of the system's performance indicate that acq/tracking system requirements can be attained provided that the jitter magnitude is small and that the optics is properly designed.

The Relationship Between Phase Refractive Index and Group Refractive Index in an Unbalanced Interferometer
Catherine Sauter
Sponsor: Arthur H. Vaughan

Measurements of the optical path difference when a dispersive medium is introduced into one arm of a Twyman-Green interferometer yield the group refractive index rather than the phase refractive index. Several different computer programs are implemented for numerical analysis of a differential equation relating these two quantities. Calculations of phase refractive index from group refractive index result a precision of four significant figures after the different methods were compared.



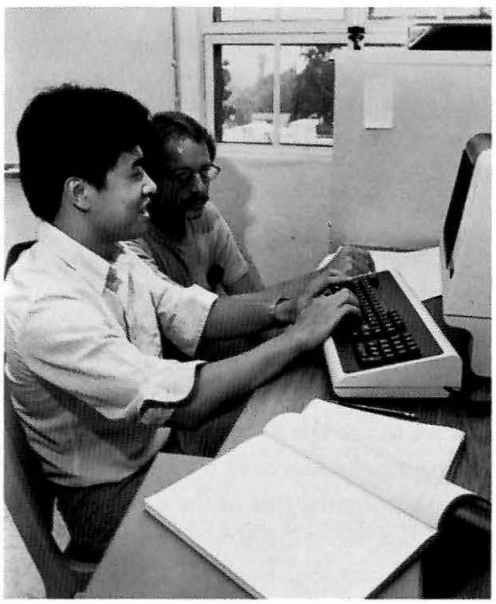
Spacecraft Constraint Checking on the Hypercube
Christian A. Schalk
Sponsor: Joan Horvath

Spacecraft perform activities in response to low-level commands received from earth. Before transmission to the spacecraft, these commands are checked by the "SEQGEN Checker" program. We developed hypercube parallel algorithms for Checker routines to allow them to run more quickly than the current sequential version. We used a variant to the Chandy-Misra paradigm with some features of Time Warp added. In particular, we used some known spacecraft command features to predict into the future the behavior that might result from a given command. We expect a speedup of about two on a four-node machine if these predictions were correct 90% of the time.

MicroMITES Structural and Thermal Design
Tal Schwartz
Sponsors: Robert C. Clauss and Edward C. Posner

This project consisted of first designing the MicroMITE satellite structure. In doing so, several conditions were considered: 1) Total satellite mass must be under 10 kg(22 lbs), 2) fabrication must be relatively easy and reliable, and 3) the satellite must be able to survive the launch environment and operate in the thermal environment of space. Next, an analysis was made of the stress and vibrational characteristics of the different satellite parts. This analysis will ensure the satellite's ability to withstand the rigors of the launch environment. In addition, a thermal

analysis was performed to determine the temperature effects of solar radiation as the satellite tumbles in orbit. Finally, a complete structural model of the



satellite was fabricated from aluminum alloy 6061-T6, which weighed only 4.1 kg(9.1 lbs).

MicroMITES Command Receiver
Suresh Shanmugam
Sponsor: Robert C. Clauss and Edward C. Posner

The Command Receiver is an on-board circuit in the MicroMITES. Specifically, I was involved in the design, implementation, and testing of the digital part of the command receiver circuit. The other part of the receiver is the microwave circuitry which basically "reads" the signal from the antenna and triggers the digital circuitry.

In the digital circuit the signal coming in is interpreted as a command and is used to switch the on-board transmitter to one of the three modes, "high power," "low power," and "off." With the aid of suitable memory chips in the digital circuit the satellite stays in the same mode when it enters and re-emerges from the Earth's shadow.

Part of the digital circuit is the controller sub-circuit which, after reading an incoming signal, prevents the remaining circuit from reading another command for a period of 40 seconds. Also there is the timer sub-circuit which begins counting up after the last incoming command for a period of thirty days, after which it resets the transmitter to the "off" state until the next command is received.

After bread-boarding the various sub-circuits, they were put together as a whole and successfully tested.

Controlling Fuel Slosh
Raymond T. Shen
Sponsor: Fred Y. Hadaegh

The proper control of fuel slosh is key in maintaining the stability of spacecraft. However, since it is a non-linear problem, it is difficult to predict slosh behavior. Thus far, no one has successfully modelled fuel slosh dynamics. My research this summer includes implementing neural networks that will hopefully learn the dynamics of fuel slosh and predict future behavior. Once the future behavior is known, neural networks can again be used to control the sloshing effects.

MicroMITES
Hassan Y. Syed
Sponsor: Robert C. Clauss and Edward C. Posner

Power to Micro Mites satelite is to be provided by solar cells. The orbit altitude of 6000 Km put the satelite in a radiation belt. This radiation degrades the solar cell efficiency. GaAs cells start with greater output power but that power degrades rapidly. But GaAs cells are about 3 to 5 times more expensive than Si cells. So mainly due to cost, Si cells are used. To reduce radiation damage, glass covering is used. The thicker the glass, the less the degradation. With 1.52 mm thick glass, shallow junction K4 (12 mils) cell degrades by 14.5% and conventional 12 mils thick cell have 11.2% degradation. Typical mass of solar cells with 1.52mm of glass covering and silver contacts is 4.75 lb. As the angle of incident light changes the current decreases as cosine of the angle. Experiments showed that about 10 ohms load gives the maximum power. Data was taken for 0, 5, 10, and 15 ohms loads as the angle varies.

Microspacecraft Size Limits
Craig M. Volden
Sponsor: Ross M. Jones

Microspacecraft on the order of 10 kg have been judged as being feasible and enabling for a certain class of space science and exploration missions. This SURF studied how to reduce the mass of the following components: antenna, battery, camera, electronics, engine, magnetometer, particle detectors, radioisotope thermoelectric generator, and spacecraft structure. Scaling equations were produced, where possible. Fundamental limits of size reduction were discovered.

Thin Polymeric Film Electrooptic Modulators as Integrated Optics Devices
Robert B. Welstand
Sponsor: Joseph W. Perry

This report describes work on thin polymeric films doped with nonlinear optical dyes and their application as electrooptic modulator devices. Test structures were fabricated by spin coating 5% by weight DR1 in PMMA onto glass substrates, annealing, and then contact poling. Linear amplitude modulation was observed under driving voltages from 0-60 AC Volts at 8 kHz. The maximum modulation index obtained was $2*10^{-4}$ for the quarter wave point at 60 Volts. We also varied the static phase with a compensator to verify phase modulation. The absence

of phase modulation implies some mechanism other than the linear electrooptic effect may be occuring. Some possibilities are electrostriction of the film, modulation of a material absorption band, and destructive interference fringing from the étalon nature of the device.

Comparison of Simulated Oceangraphic Temperature and Current
Mark T. Wu
Sponsor: David Halpern

The Cray-2, Cray XMP and Cyber 205 computers were used to run the Numerical Model Simulation of Large Scale Ocean Circulation. The computers' data outputs, the Fisher, the Fisher(lansing XMP) and the Hurlin, respectively, included the water temperatures and currents which were numerically plotted against the longitude and performed to obtain the summary statistics; the Hurlin was taken for the reference.

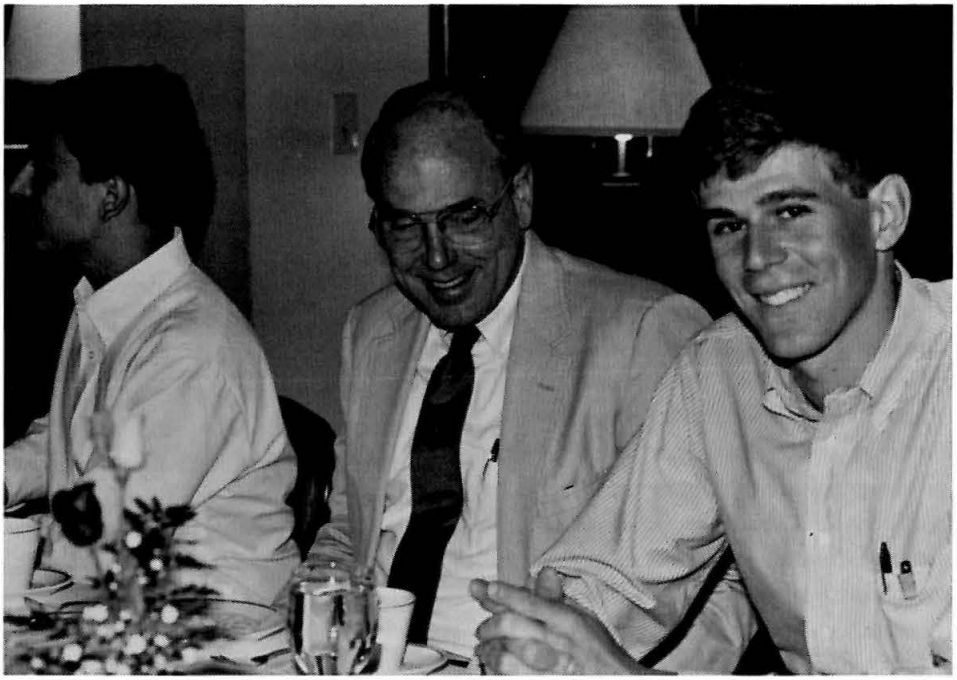
The purpose of the project was to examine to see which of the two, the Fisher or the Fisher(lansing XMP), had come close to the Hurlin. For the water temperature and current, the mean differences were determined to be: 1)-0.144 and -4.24, respectively [Fisher(lansing XMP) -Hurlin]: 2)-0.0034 and 0.170, respectively [Fisher - Hurlin]. As a result, the Fisher got close to the Hurlin because its mean differences were small difference.

High Capacity Circuit Maintenance Expert System Development
John Gass and Carlos Ramirez

The initial purpose of this summer project was to develop an expert system to receive and analyze trouble alarms from Pacific Bell's high capacity circuits (HICAPs), which are dedicated lines provided to certain customers, such as large businesses. We performed extensive research into the feasibility of various options and presented our results to knowledge engineers, as well as compiling a report of suggestions for process improvements. Our work has contributed to the development of plans, which are currently being formalized, for implementing one such expert system.

The Source of Charge in a Single Source Double Layer Plasma
Chad A. Roberts
Sponsors: Raymond T. Carpenter and Thomas A. Tombrello

Plasma double layers were created with a differentially pumped triple plasma device using only one of the two plasma sources and biasing it positive relative to the rest of the device. To determine the source of the electrons at the low potential side of the double layer, data was taken under conditions of varied magnetic field, neutral pressure, discharge voltage, discharge current and bias voltage. A cage of wire mesh was placed in the central chamber and biased relative to it in order to determine if electrons were being released from the wall due to ion bombardment and contributing to the double layer.



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