Summer

Undergraduate

Research

Fellowships

California Institute of Technology

Tenth Anniversary

Again this year, for the fourth 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), Vice President and General Manager, for their personal support as expressed through AMETEK.

Dedication

We dedicate SURF 1988 to Dr. Ray Owen, Professor of Biology, Emeritus. His work in genetics and immunology, his commitment to teaching, and his continued interest in the welfare of students have contributed immeasurably to the quality of education at Caltech.

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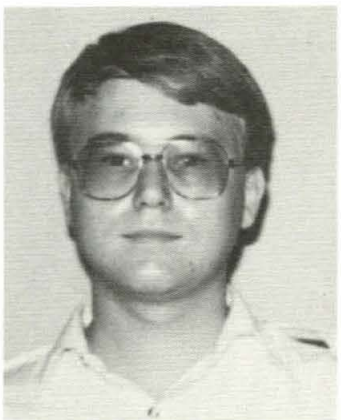


In Memoriam
Peter A. Lindstrom, Jr.
October 5, 1968 - July 1, 1988

Peter Lindstrom, a senior in chemistry, died in an automobile accident on July 1, 1988. He had begun to work on his second SURF project a week earlier. His gentle ways and generous spirit will be remembered by all who knew and befriended him; his unrelenting dedication to research will inspire us for years to come.

President's Message

Ten years ago, when the first 18 SURF students began their summer of research, SURF's founders and sponsors anticipated a successful and ongoing program. But the phenomenal growth they have seen—almost a tenfold increase in the number of student researchers—has surpassed all expectations. I am pleased to have joined an institution where the hard work and support of so many dedicated people have resulted in a superb program such as this. I look forward to being part of SURF's continued growth.

Thomas E. Everhart
President
California Institute of Technology

Chairman's Message

My service this past year as Chairman of the SURF Board was particularly rewarding for me in light of SURF's tenth anniversary. One highlight was the opportunity to work closely with the capable faculty and staff of the Institute and with the remarkably talented students of the SURF class of 1988. Another highlight was my continuing association with the splendid group comprising the SURF Board. Little did I know when Samuel Krown first introduced me to the SURF program several years ago that it and my participation would increase so dramatically.

The SURF class of 1988 numbered 173, the largest to date. This years's SURFers were representative of all undergraduates at Caltech who, together with our faculty, constitute a rare community of scholars. The SURF opportunity adds a priceless ingredient: SURF students and faculty working as a team, producing new ideas and new knowledge. I am proud of their results.

Financially, we will end the year in reasonably good shape. The uncertainties of government support, however welcome that support may be, make it difficult for the faculty and staff to accurately predict early in the year just how many students can be admitted into the SURF program. This year, unanticipated changes in the federal College Work Study program regulations and a decrease in funding from the National Science Foundation have been problematic. On the plus side, I am happy to report there has been an increase in the number of privately-funded SURF endowments, and in the long term this will serve us well; a corresponding increase in private gifts earmarked for annual operating purposes would be helpful, and we must continue to work on that.

During the summer, we were all saddened to learn of the tragic death of SURFer Peter Lindstrom in an automobile accident. The Board joins the members of SURF '88, their faculty sponsors, and the entire Caltech community in a deep expression of sympathy to Peter's family.

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

Hugh F. Colvin
Chairman, SURF Board

The Complete Solution

by Ray D. Owen
from his speech at the 1988 SURF Kickoff Dinner

In 1967, Niels Jerne, a distinguished immunologist who was to receive a Nobel Prize nearly twenty years later, gave the summary lecture at the end of a Cold Spring Harbor Symposium on Antibodies. He titled his talk, "Waiting for the End." His predominant theme was that we were, in 1967, on the brink of the final solution of the antibody problem, and it might well be time for established scholars in immunology to sit back, waiting for the End as the final touches were completed by younger people. In 1969, Jerne pressed this theme further, in a paper published in the *Australian Annals of Medicine* entitled "The Complete Solution of Immunology." He posed twenty questions about immunology, asserting that ten of them were already answered, and that "the remaining ten will be answered quite soon and—these answers will constitute the complete solution of immunology." After that, he wrote, "I wonder what scientists will be doing during the following thousand years. In fact, I think they will be doing nothing, because all scientific knowledge worth knowing will be known. The scientific era will draw to an end, and will turn out to have been only a period of some hundred years in the history of humanity."

I find it interesting that the date, 1969, coincides with the publication of Gunther Stent's thoughtful and provocative book, *The Coming of the Golden Age (A View of the End of Progress).* Stent, also a distinguished scientist (he achieved distinction partly as an associate of Max Delbrück here) chose "classical genetics" as "the first example that I bring up for consideration in these chapters of how an age-old domain of human inquiry experiences at first a very slow development over millennia and centuries, then speeds up its rate of progress, and finally brings about the solution of the problems posed by its frame of reference. At this stage the field changes in character, since its very success has made it a less attractive arena for romantic strife. The field has now lost its appeal for the kind of person who is driven to explore uncharted territory. Scholars and technologists replace the knights-errant and work out the details."

For both Jerne and Stent, the End is to be preceded by an interval when everything interesting is known, and people are occupied in dull routines, tidying up. Jan Klein, in his excellent textbook of Immunology (1982)—13 years after the Jerne and Stent prophecies—tells the story of the Hunger Wall:

In the fourteenth century, there lived in Bohemia an enlightened king, Charles IV. He did many good things for the country—built beautiful cathedrals, castles, and bridges, and, in general, tried to keep the citizens reasonably happy. So when unemployment in Prague rose to threatening proportions, he thought of an ingenious way to bring it back to normal. He ordered the building of a new wall around the city of Prague. The wall was not an absolute necessity—the city could have lived without it. The ruins scattered all over Europe testify to the fact that walls never did provide much protection. But the construction created new jobs and saved

people from dying of hunger. This wall still stands, and the Czechs still call it the Hunger Wall.

I see such a Hunger Wall being erected in immunology today. Not a castle, not a cathedral, not even a bridge—but a plain wall, and not a very functional wall, at that. Stone after stone, article after article—they disappear as the wall grows longer and longer. There is always another It *gene to discover, another organism to study, and the supply of T-cell factors seems to be inexhaustible. A gene, a phenotype, an organism—a publication. A stone in the wall. And when the stone does not fit, when the results are not reproducible, there is always the difference in experimental conditions to explain away a discrepancy. Whether it fits or not, the stone becomes anonymous within a few years after it has been quarried. The wall keeps many scientists busy, employed, and happy. One has to make a living somehow.*

It is not only in immunology or genetics that one encounters rather frequent expression on the part of "old-timer" scientists that their fields are approaching an end, and that even if it is not all over quite yet, it is surely going to be dull from here on in, especially as compared with the exciting days of their youth. Many of these depressing predictions have had time to be tested; none of them, so far as I know, were right. At the 1976 Cold Spring Harbor Symposium for example, nine years after his "Waiting for the End," Jerne observed that immunology was flourishing, better than ever, and was involved in research areas, mainly through the remarkable advances in molecular genetics, that could not have been envisioned in 1967. So much for the twenty questions about immunology, the answers to which were to provide the complete solution; one could not even have asked the questions to which unforeseen advances were providing new answers.

But then in 1983 (seven years later) Jan Klein in a review concluded that even the molecular genetic approach was in its "Final Act," at least with regard to one very important and challenging system, the major histocompatibility complex (MHC). He wrote,

...the astonishingly rapid progress of the molecular genetics of this system leaves no doubt that the answers will be provided within the next few years. It is as if molecular genetics has raised the curtain on the final act of the MHC play, and as in every good play this act is turning out to be short and packed with action. It truly was a good play: dead-earnest most of the time, hilarious on occasions, and thrilling all the time. Seeing it nearing its end, one cannot help but feel a sting of nostalgia. For to some of us the play has become part of our lives and after the last cur-

tain call we will realize, undoubtedly, that something more than a good play is over.

But this was followed just a year later by a review in which other authors, one of them a Caltech alumnus, observed:

...the curtain has only just risen. The diversity of the unsolved questions—and the application of new technologies—promise to provide a rich and fertile area of research for years to come.

So, on one hand you have an extreme—some old-timers predicting the end of progress. There is another extreme—some youths who are sure that practically nothing was known in their fields of science before they entered them, and that more is being learned in a year today than was learned in a century before them. Youth's confidence that it is all fresh is doubtless part of the exhilaration of research, and in that sense it is good. I am convinced that some things need to be experienced anew after they have been forgotten as a science pursued newly popular lines; they can't just be dug out of the aging literature to much effect. But it is worthwhile, more than just interesting, to pay attention to what people were thinking in the past. For example, in immunology, Erlich in 1900 was closer to the truth about antibody origins than Pauling was in 1940. It took molecular genetics to make the correction, and we returned about 1960 not to Erlich's earlier truth, but to a turn above it in the helix of advancing understanding. Pauling himself made important basic contributions to the truth that discredited his own theory.

The best, perhaps the only, way for the young to equip themselves for a life in Science is by experiencing it, by getting into real research. Textbooks, lectures, homework, exams or even classroom labs cannot substitute for that experience. This is a truth long recognized at Caltech. The spirit of SURF—of undergraduate research as an important part of the education of a scientist, is by no means new here. But, SURF is nevertheless unique in vital ways. For one, it *funds* undergraduates for intense research experience during uninterrupted summer periods, through to the important experience of communicating the process and the results at the end. Especially these days, the funding makes an enormous difference. Gone are the times of unlimited scholarships, when a student didn't need pay in the summer, and could work as an unpaid volunteer, often at dishwashing. Now, students are expected to earn summer income, and to an old-timer the expectation seems awfully large these days with the high costs of tuition and other aspects of getting a Caltech-quality education. Besides the unique values in the structure of the program itself, this is why SURF has come to play so key a role, why Fred Shair's dedication and the hard work of Carolyn Merkel and others so greatly deserve our

gratitude and respect, and why the supporters of SURF can properly feel so warmly and genuinely appreciated, and why their support is so good an investment.

There is a general impression that prizes are great motivation for doing science, and I guess giveaway prizes do in fact help to motivate some people. Somewhat similarly, recruitment by inclusion of "strictly merit" scholarship awards in addition to need- and merit-based financial aid may sometimes be effective. In that sense, the award of a SURF is a prize, much to be valued as a recognition of merit. But it is more than a give-away prize; it is an opportunity to *work* as a scholar and get paid for it. And though it is not formally "need-based," it is needed. So if this is our "kickoff" for SURF in '88, we recognize it as a continuing effort to kick the ball clear out of the end zone. We should be very disappointed with a squib.

Finally, particularly to the young, and returning to my starting theme: When an old-timer tries to tell you that his science is on the brink of "complete solution," that you won't have much to do for long, and that in any case it can't help but be dull, *don't be discouraged.* Maybe the old-timer is just a little tired. It is true that sometimes you are likely to feel that you are only placing a stone in a Hunger Wall, and, even worse, your stone may not seem to fit anywhere at all. But I will continue that quotation from Jan Klein: "But in addition to Hunger Walls, scientists also build cathedrals, castles, and bridges." And I will add that walls are part of castles and cathedrals too. Only time may reveal that your apparently ugly little misfit stone is really the cornerstone for a new castle.

Reflections from a Golden Pond

by Fredrick H. Shair

Completing its tenth year, the SURF program has made an outstanding positive contribution to the undergraduate program at Caltech and has influenced universities throughout the country. Following the 1988 SURF program, a total of 903 Caltech undergraduate students have SURFed. This number is approximately 11% of the living Caltech alumni who were undergraduates at the Institute.

The Original SURF Program

Undergraduate research at Caltech did not actually start with the SURF program. In our first newsletter, Ernest Swift (1897-1987) reported: "Undergraduate research was introduced into the curriculum at Caltech by Arthur A. Noyes after his arrival in 1920 as the first Chairman of the Division of Chemistry. This was probably the first extended use of undergraduates in scientific research anywhere." About a dozen students would spend a summer conducting chemical research at Caltech's Marine Biology Station at Corona del Mar. One of these investigations led to a publication by Edwin McMillan and Linus Pauling: "An X-ray Study of the Alloys of Lead and Thallium," *Journal of the American Chemical Society*, Vol. 49, p. 666, 1927. Both authors continued their research careers and both later won Nobel Prizes in chemistry. "Noyes believed that students of chemistry should be introduced to research as early as possible," wrote Linus Pauling in "Arthur Amos Noyes, a Biographical Memoir," in the Biographical Memoirs of the National Academy of Sciences of the United States.
However, the original summer program disappeared in the mid-thirties for the lack of financial support and campus-wide participation. Lessons learned from the original program were that undergraduate research is quite feasible and highly desirable, and without institution-wide involvement and assured financial support, even a good program can disappear.

Birth of The Modern SURF Program

The SURF program was born in 1979 out of debate within the Scholarships and Financial Aid Committee. The committee was charged with distributing some of the President's Prize Fund to undergraduates. The only restriction was that distribution be based upon perceived merit rather than upon financial need. Some members of the committee argued that all Caltech students were meritorious and deserving, while others argued the Prize money should be given only to students who had demonstrated academic excellence. The concept of SURF, developed by Hal Zirin and Fred Shair, represented a resolution of the debate. They also considered that NSF was phasing out its Undergraduate Research Participation (URP) program. The loss of the NSF-URP program would adversely affect approximately 20 undergraduates throughout the campus. The members of the committee (Ursula Hyman, Andrew Ingersoll, Bernard Minster, Forrest Nelson, William Schaefer, Fred Shair, and Hal Zirin) unanimously believed some of the Prize money should be used to support students who developed meritorious proposals and with whom the faculty wanted to work. In this way SURF would not only reward meritorious achievement but would create new opportunities for professional growth. The summer was chosen because the student members of the committee felt that it was the best time to introduce students to research.

A memo from the committee to President Marvin Goldberger, Provost Robert Christy, Vice President David Morrisroe, and Vice President William Corcoran, outlined the basic program and contained a request for financial support from the Prize Fund. After checking with the donor of the Prize Fund, the request was granted.

Purpose of SURF

The purpose of the program is to encourage professional creativity and growth of Caltech undergraduates; to enhance interaction between undergraduates and the faculty/JPL staff; to help our undergraduates in their career decisions; and to provide an outreach program involving emeriti professors, admissions, alumni, donors, JPL, and other institutions to help Caltech achieve its institutional goals.

The Goal of The SURF Administrative Committee

The goal of the SURF Administrative Committee is to fund every good proposal, defined as one in which both the faculty and student express a great deal of enthusiasm for working together on the proposed project. In short, the goal of SURF is to enhance the player-coach relationship between undergraduates and professional researchers.

Quality Assurance

Over the years, the research sponsors have become effective at screening out weak proposals, thus making the SURF Administrative Committee's work much easier. The quality of the SURF program has come to rest upon the judgment and decision of the research supervisors, and they have done an excellent job.

Formal Institutional Commitment

The SURF Administrative Committee was formed in 1984 by President Marvin L. Goldberger. This made it easier to raise funds since potential donors could see the institutional commitment and could interact with the faculty who had formal responsibility for the program. Dr. Goldberger placed the SURF Administrative Committee under the Vice President of Student Affairs and charged it with "the planning and administration of the SURF program each year," and "providing the administration with advice on the long-term planning and development of the SURF program and possible related programs which may evolve in the future." President Thomas E. Everhart expressed his support for SURF in his inaugural address, and his continued interest is most encouraging.

Summary of Participation by Students and Faculty

SURF has grown steadily over the past ten years. In 1979, 18 students worked with 17 faculty. In 1988, 173 students worked with 97 faculty, 17 JPL staff, and five sponsors from other institutions. During the first decade, 903 Caltech undergraduates and 35 students from other universities participated in the Caltech SURF program. One hundred ninety-one (54%) of the professorial faculty in science and engineering, 17 members (30%) of the professorial faculty in Humanities and Social Sciences, and 72 JPL technical staff participated as research supervisors. In addition to the current members of the SURF Administrative Committee, others who have served were Charles Babcock, Don Browning, Richard Dean, and Susan Pearce.

Financially, a majority of the faculty and virtually all of the JPL staff have designated research funds to be used in the financial support of their SURFers.

In addition to supervising the SURFers, providing financial support, and serving on the Administrative Committee, Caltech faculty and JPL staff have presented 83 overview seminars to SURFers. These overview seminars, given during informal lunches, have ranged from specific research fields to areas of professional development.

Summary of the Participation by Caltech's Friends

Samuel P. Krown, SURF's initial financial supporter, generously lent his leadership in the critical early stages of the program and helped form the SURF Board, an organization of representatives of corporations and foundations and other individuals who are dedicated to the educational values of undergraduate research at Caltech. The Board, through their volunteer efforts, advice, encouragement, and financial support, contribute to the vitality, continuity, and effectiveness of the SURF program. In addition to gifts from the members themselves or from the organizations they represent, the Board collectively engages in promotional and fund-raising activities in direct support of the SURF program. The chairpersons of the SURF Board have been Samuel Krown and Betty Nickerson. During SURF's first decade, 121 persons, 16 corporations, and 4 foundations gave financial support to the program.

Dedication

Each year since 1985, we have dedicated the SURF program to a professor emeritus whose life made an extraordinary impact upon the undergraduates at Caltech. SURF has been dedicated to Ernest Swift, Lee DuBridge, Robert Sharp, and Ray Owen.

Administration and Management of SURF

The SURF Administrative Committee sets general policy for SURF. Carolyn Merkel has handled the day-to-day management of SURF with help from Ed Baum, Joan Spears, Jean Cass, and Fred Shair. SURF management is lean; 89% of the money given goes directly to student stipends.

Endowment of SURF

One of the lessons learned in the original summer research program was the need for committed financial resources. We are especially grateful to Samuel P. and Frances Krown, who in addition to the gift of their unflagging energy in the promotion of SURF, established the SURF endowment as a major step towards achieving continued funding. Other visionary individuals, corporations, and foundations, have also contributed to the endowment which now totals approximately $1,300,000. About $7,700,000 more is needed to fully endow the program. In addition, friends of Peter Lindstrom have set up a memorial fund which they hope will become a SURF endowment in Peter's name.

Reflections

Because of the traditions at Caltech and JPL, the interest of the Caltech faculty and JPL staff in research, the enthusiasm and quality of the Caltech undergraduates, and the support of our administration, the Caltech alumni, and other extraordinary friends of Caltech, the development of the SURF program has been exhilarating.

Participating in the development of SURF with the Caltech faculty and JPL staff, the students, the administration, and the donors has been a truly exceptional experience for all of us. It has not always been easy, but it has been tremendously satisfying.

The advice and support given by Lew Allen, Robert Bacher, William Bridges, Donald Cohen, William Corcoran, Lee DuBridge, Harry Gray, Ted Hurwitz, Allen Lindstrom, James Morgan, Ray Owen, Robert Sharp, Ernest Swift, William Whitney, Robbie Vogt, Hal Zirin, members of the SURF Administrative Committee, and members of the SURF Board have helped shape the program as it evolved. Their counsel has been essential, and their encouragement greatly appreciated.

In one sense it has been like viewing a golden pond on an autumn afternoon; focusing upon its beauty has kept us inspired.

Thinking back to 1979, and the loss of NSF-URP support for undergraduate research, we are reminded of a statement in Louis Lamour's book, *Lonely on the Mountain*: "There will come a time when you believe everything is finished. That will be the beginning."

Research Sponsors as Mentors

The ideal condition
would be, I admit, that men
should be right by instinct;
But since we are all likely
to go astray, the reasonable
thing is to learn from those
who can teach.

Sophocles, in *Antigone*

Research sponsors are more than qualified teachers for undergraduate researchers; they are mentors. The mentor-protege relationship encompasses not only research but also the relationships within the research group, the economics of research, and the general climate of the department or the institution. The sponsor-SURFer, mentor-protege relationship is the key element in the integrated learning process of undergraduate research.

Students and members of the Caltech faculty and JPL technical staff begin to develop this relationship during the application process, beginning in January. The student initiates conversations with potential research sponsors to discover whether the sponsor has a project that might be suitable for a SURF. During these discussions, students and sponsors are encouraged to interview each other, to ask questions, and to define expectations. The sponsor provides an overview of the project and may suggest additional reading for the student.

This early interaction is important. It permits the student and sponsor to begin to establish a working relationship. It gives the student the time and opportunity to acquire background information about the subject and thereby shortens the time it takes to become a productive member of a research team.

When the faculty member and student agree on a project, the student writes a proposal, which is first evaluated by the research sponsor and then submitted to the SURF office along with three letters of recommendation from other members of the Caltech community. The sponsor is the first reviewer of the proposal. As a result of this initial and most critical screening, very few weak proposals are submitted to the SURF office.

Proposals and letters of recommendation are further reviewed by members of the SURF Administrative Committee; each committee member reads the proposals in his area of expertise. The reviewers assess the enthusiasm of both the sponsor and the student for the project and for working together and recommend awarding SURFs as follows: (1) *Outstanding proposal*—sponsor extremely enthusiastic, strong letters of recommendation, must fund; (2) *Excellent proposal*—sponsor enthusiastic, strong recommendations, recommend funding; (3) *Good proposal*—sponsor moderately enthusiastic, good recommendations, fund if money is available; (4) *Weak proposal*—sponsor neutral, references neutral, recommend no funding. The actual number of students awarded a SURF is contingent upon the amount of money available for stipends.

The overarching goal of the program is to fund every proposal ranked "1" or "2." Of the 218 proposals submitted this year, only three were rated "4" by the SURF Administrative Committee.

Summary of the applicant pool:
Total number of SURF applications: 218
Total number of Caltech applicants: 196
Number of non-Caltech applicants: 22

Summary of the recipient pool:
Total number of awards: 176;
173 students completed their SURFs.
Number of Caltech students receiving awards: 156
Number of non-Caltech students receiving awards: 20
Percentage of Caltech applicants receiving awards: 80%
Median GPA: 3.5
Percentage of eligible Caltech student body (entering sophomores, juniors, and seniors) participating in SURF-88: 25%
Number of professorial faculty participating in SURF '88: 84

Summary of the 1988 SURF Class

Divisions & Options	No. of Sponsors	No. of Students
Administration	1	1
Biology	10	17
Chemistry and Chemical Engineering		
Chemistry	9	12
Chemical Engineering	4	6
Engineering and Applied Science		
Aeronautics	3	3
Applied Mathematics	1	1
Applied Physics	3	3
Civil Engineering	2	3
Computer Science	3	4
Electrical Engineering	2	3
Environmental Engineering Science	2	3
Materials Science	2	2
Mechanical Engineering	1	1
Geological and Planetary Sciences		
Geology	3	5
Planetary Science	3	6
Humanities and Social Sciences		
Economics	2	2
History	3	4
Literature	1	1
Social Science	5	5
Physics, Mathematics and Astronomy		
Physics	18	25
Mathematics	6	8
Astronomy	7	7
Computing	3	12
Computation and Neural Systems	3	6
JPL	17	27
Off-Campus	5	5
TOTAL	119	173

Financial Notes

Contributions to SURF for the 1988 program from the Institute, JPL, faculty grants, individuals, corporations, and foundations are estimated at $580,181. Student stipends account for 89% of total contributions; administration costs 11%.

National Science Foundation Grants

The SURF staff submitted proposals to the National Science Foundation's Research Experiences for Undergraduates (NSF-REU) program. Caltech was awarded grants in computing and math. In 1987 a three-year grant from the same program was awarded in chemistry. These grants have funded a total of 27 students, 10 of them from other institutions.

Off-campus SURFs

Caltech's experience in 1987 and 1988 sponsoring non-Caltech students through the NSF-REU was excellent. The Caltech students appreciated meeting students from other campuses. The non-Caltech students were enthusiastic about their experience and some have already made inquiries into graduate study at Caltech.

Working at Caltech and JPL this summer were twenty students from campuses which included Amherst College; Brandeis University; ENSAE and SEP, France; Harvard; MIT; Occidental College; Pitzer College; Stanford; University of California at Berkeley; UCLA; University of California at Irvine; University of California at Santa Cruz; and University of Pennsylvania.

An exchange of undergraduate students among institutions for the purpose of doing research projects during the summer appears to be a wave of the future.

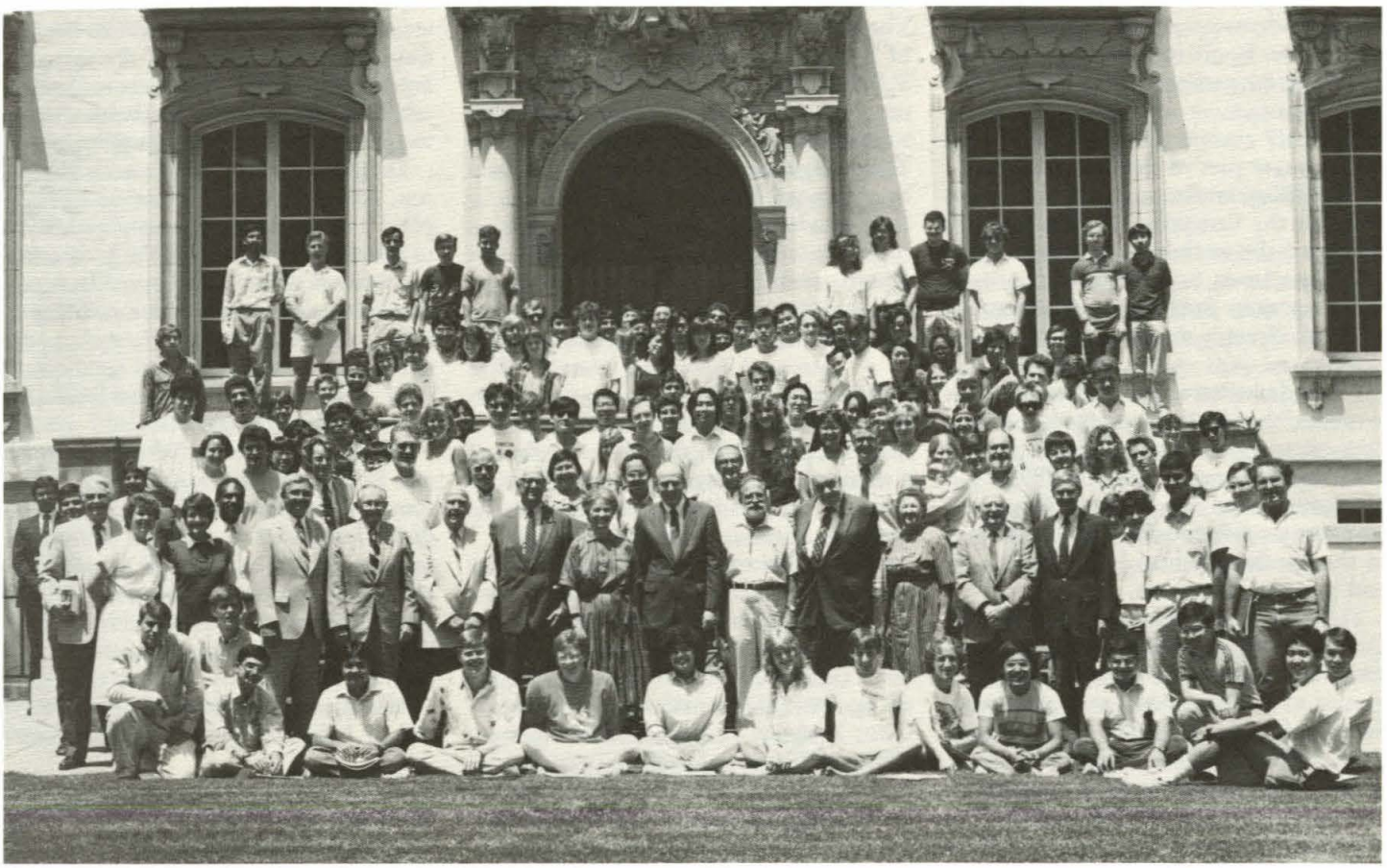
Twelve Caltech students arranged SURFs in other locations: Heidi Anderson worked in Kentucky; Eric Candell arranged his SURF at Louisiana State University in the Department of Physics and Astronomy; Gabriela Cornejo traveled to Tennessee; Ruchira Datta SURFed at AT&T in Denver, Colorado; Lisa Giamo worked in New Zealand; Susan Howard traveled in 32 states; Thu Le did her SURF project at the University of the Western Cape in South Africa; Vijai Maheshwari studied in India; Fred Roeber SURFed at CERN in Switzerland; Kevin Underhill worked at TRW, Redondo Beach; Miriam Yee SURFed at the Scripps Institution of Oceanography, La Jolla; Kyuson Yun worked at MFI in Basel, Switzerland.

Awards and Honors

Gerard Wong, a 1986 SURF student, was awarded the Apker Award of the American Physical Society, a prestigious national prize presented to the student doing the most outstanding piece of physics research as an undergraduate. Wong worked with Dr. Eric Cotts, a postdoctoral fellow in Professor William Johnson's research group in materials science. The work that began as a SURF culminated in a senior thesis, "Solid State Reactions in the Ni-Zr System," a study of the thermodynamics and kinetics of the solid state amorphization process.

Peter Lindstrom (SURF '87 and '88), Karen Oegema (SURF '88), and Eric Scharin (SURF '87) were this year's recipients of the Schuster Memorial Prize, given to junior or senior students in chemistry or chemical engineering who have shown good academic promise.

The Undergraduate Academic Standards and Honors Committee, the division chairmen, and the deans selected 1986 and 1987 SURFer Randall Kamien to receive the Sigma Xi Award. This award is presented annu-



ally to a senior for an outstanding piece of original scientific research.

Rachael Clark (SURF '86 and '87) won a Monticello Foundation award to do a research project at another institution. She worked last summer with Dr. Nancy Ascher at the University of California, San Francisco Medical School on "Isolation and Characterization of Immunosuppressive Factor Found in Human Hepatocytes."

Rachael also received the Arie J. Haagen-Smit Memorial Award, presented at the end of the sophomore or junior year to a student in biology or chemistry who has shown academic promise and who has made recognized contributions to Caltech.

Dawn Sumner (SURF '87 and '88) was awarded the George W. Green Memorial Prize, presented to an undergraduate in any class for original research, an original paper or essay, or other evidence of creative scholarship beyond the normal requirements of specific courses.

Ken Haynes was awarded a Watson Fellowship to do a complex investigation of the classical role of the city in man's perception of himself. Ken, who graduated in 1988 with a physics major, SURFed in 1987 with Professor of Literature Ron Bush on "The Italian Background to the *Cantos*," and in 1986 with Dr. Carne-Ross, Aurelio Professor of Greek and Professor of Classics and Modern Foreign Language at Boston University on "The Guilt and Innocence of Oedipus."

Andrew Huntington (SURF '86) and David Lipin (SURF '87) won the Robert L. Noland Leadership Scholarship, a cash award for upperclass students who exhibit qualities of outstanding leadership. The kind of leadership to be recognized is most often expressed in personal actions that have helped other people and that have inspired others to fulfill their leadership capabilities.

Communications Workshops and Speakers Bureau

When SURF initiated its Communications Workshops under the leadership of Jean Cass seven years ago, approximately 30 students spent two hours in a workshop learning the elements of public speaking. Since then, Jean has expanded the communications program to include workshops in technical writing, oral presentations, and creating

visual aids to enhance such presentations. Students now spend approximately four hours in workshops and many more hours rehearsing their presentations.

As SURF encourages the students to take a larger part of the leadership and responsibility in the program, this year, for the first time, a student presented the workshops on visual aids. Ann Lewis, a member of the SURF Speakers Bureau, led nineteen students through the workshop curriculum.

As students have become better speakers, they have been asked to address groups both inside and outside the Institute, and in 1987 the SURF Speakers Bureau was formed. Twenty students are selected for membership in the Speakers Bureau by audition and personal interviews.

SURFers spoke at the annual Kickoff Dinner in January. The Alumni Association invited students to speak to groups of alumni as well as at Alumni Seminar Day for each of the past three years. Public service groups in the community began requesting speakers; and Caltech's Public Relations and Admissions offices now use the Speakers Bureau. Perhaps the most exciting aspect of the SURF Speakers Bureau program has been the opportunities for students to address groups of high school students in the greater Los Angeles area, thus building bridges between the Institute and many of the local area high schools from which Caltech draws a number of entering freshmen.

The Speakers Bureau holds monthly meetings where members give a presentation for criticism by the group. The students are coached on giving technical presentations on their work that are understandable to lay audiences and to speak on non-technical topics concerning various aspects of Caltech.

SURF Library

The SURF office is developing a library of books and periodicals of interest to SURFers. The collection contains books on oral and written communication; a subscription to *Issues in Science and Technology*, the Proceedings of the Second Annual National Conference on Undergraduate Research; the ten-year collection of SURF students' final reports, the SURF Annual Reports; and reprints of articles published in scientific journals by SURF students.

Leadership Roundtable

Each summer SURF offers a series of Leadership Roundtables. Each involves a small group of students meeting informally with leaders in given fields: corporate executives, members of the Institute administration, distinguished alumni.

This summer's initial roundtable, under the leadership of Caltech's President Thomas E. Everhart, was attended by seven SURF students; Dr. Bruce Cain, Professor of Political Science; Dr. William Whitney, Division Technologist, JPL; and Dr. Martin Leipold, Sensor Program Coordinator, JPL. The discussion for the session centered on issues relating to development of science policy and the training of scientists and engineers.

Mr. Hugh Baird, Caltech alumnus, and retired president of C F Braun, led students in a discussion of career development from technical research into management. He particularly stressed the value of clear written and oral communication.

"Executive Qualifications for the Twenty-First Century" was the topic Mr. Robert Shafer, a retired Management Consultant, chose to discuss with a group of SURFers. The students identified and discussed several qualifications necessary for twentieth century executives and how these will change over the coming years.

Mr. Victor Veysey, Caltech alumnus, Director Emeritus of Caltech's Industrial Relations Center, former California Assemblyman, and U.S. Congressman, led the fourth Roundtable. The lively discussion revolved around the many aspects of politics, from international relations and nuclear non-proliferation to the politics of a research group.

Dr. James Workman, Caltech alumnus, and now Staff Scientist at Applied Theory, Inc., met with students to discuss the importance of good communication skills. In his opening statement, he outlined the value of being able to communicate clearly and concisely about one's work in a technical field to audiences outside the field—including funding agencies.

Mr. Robert Perpall, Caltech alumnus and Retired President of Garrett Automotive Products Company, was the discussion leader at the final summer roundtable. He stressed the importance of becoming a "holistic scientist or engineer," developing interests and relationships aside from one's academic or business focus.

Additional roundtable discussions will be held during the academic year.

Seminar Series

Each summer the SURF program sponsors a series of seminars presented by Caltech faculty and JPL technical staff members. The speakers give an overview of the work being done in their research groups. The seminars are held at noon on each Wednesday of the SURF program. Speakers this summer and their topics were:

Geoffrey A. Blake, Assistant Professor of Cosmochemistry and Planetary Science, "Chemistry and the Birth of Stars and Planets;" Roger D. Blandford, Professor of Theoretical Astrophysics, "Gravitational Lenses;" Dr. Donald J. Collins, Deputy Manager of the Atmospheric and Oceanographic Sciences Section and Program Manager for Oceanic Processes in the Office of Space Science and Instruments at JPL, "Remote Sensing: A Tool for the Study of the Role of the Ocean in

Global Climate;" Jeffrey A. Dubin, Associate Professor of Economics, "The Economics of Tax Compliance;" Earl J. Freise, Director of the Office of Sponsored Research, "Get Me to the Trough on Time;" David L. Goodstein, Professor of Physics and Applied Physics, "High-Temperature Superconductivity;" Mary B. Kennedy, Associate Professor of Biology, "Chemistry of Synaptic Transmission in the Brain;" Christof Koch, Assistant Professor of Computation and Neural Systems, "Computing Motion in Resistive and Neuronal Networks;" Edward E. Zukoski, Professor of Jet Propulsion and Mechanical Engineering, "The Fire in the First Interstate Bank Building in Los Angeles and Fire Research at Caltech."

Dr. Steven Witherly, Manager of Scientific Research, Carnation Company, presented a special seminar to the students and other members of the Caltech community on "Chocolate: Physiology and Perception," complete with chocolate samples.

SURFers Tour JPL

Dr. Terry Cole, Senior Faculty Associate in Chemistry and Chemical Engineering at Caltech and Chief Technologist at JPL, and Sheila Reever, Supervisor of Placement, Recruiting and Employee Relations, JPL, arranged a program and tour of the Jet Propulsion Laboratory on June 16. The students viewed the movies "Welcome to Outer Space," "LA the Movie," and "Miranda the Movie," presentations using computer-enhanced satellite photography. Following the presentation in the von Kármán Auditorium, the students toured the hypercube computing facility, the micro-devices laboratory, the Galileo Spacecraft, and the Space Flight Operations Facility, and had dinner in the cafeteria.

Math Seminars

Because of the National Science Foundation REU grant obtained by Fred Shair and Richard Wilson, the math department had an unusually large number of mathematics undergraduate students supported this summer as part of the SURF program. The department organized a series of bi-weekly talks by research mathematicians. The format was a talk between 11:00 AM and 12 noon followed by lunch with the speaker. All the math SURFers, math SURF friends, and other interested math students were invited. Results of a questionnaire distributed after the last talk showed the participants enjoyed the programs and wanted a similar program next year.

Topics for the math seminars included: "Knot Theory" presented by Dr. David Gabai, Professor of Mathematics; "Logic," Dr. Alex Kechris, Professor of Mathematics and Dr. Hugh Woodin, Professor of Mathematics; "Combinatorics," Dr. Richard Wilson, Professor of Mathematics; "Groups," Dr. Michael Aschbacher, Professor of Mathematics; "Statistics," Dr. Gary Lorden, Professor of Mathematics.

SURF Seminar Days

SURF Seminar Day was held on Saturday, October 15, and was attended by some 250 people. As part of the SURF contract, each student gave a 20-minute oral presentation of his or her work to audiences of peers, faculty, parents, and friends of SURF. This year there were eighteen concurrent sessions during the afternoon. The Seminar Day activities began with a buffet luncheon in Dabney Garden. The seminars were given between 1:00 PM and 4:30 PM. President and Mrs. Everhart hosted a reception in their garden for the students, faculty, parents, and friends of SURF following the presentations.

The students from other colleges who SURFed at Caltech presented their final oral reports on August 18 before they returned to their respective campuses. Twelve students gave 20-minute presentations to audiences of students, research sponsors, members of their research groups, other faculty, and staff.

Students Take Leadership Roles in the SURF Program

SURF is a program *for* students, and students are encouraged to assume leadership roles. Students take the responsibility of chairing the sessions on SURF Seminar Day; they introduce the speakers and assist with lunches and visual aids at the Seminar Series. Student assumption of leadership and responsibility in the program helps fulfill one of SURF's goals: to encourage professional creativity and personal growth of undergraduate students.

Increasing Interest in Undergraduate Research Throughout the Country

The Council on Undergraduate Research held its second conference at Carleton College, Northfield, Minnesota, on July 13-14, 1988. A total of 455 persons attended from academic institutions and government.

Colleges throughout the country are reviewing their undergraduate curricula and attempting to increase the opportunities for undergraduates to conduct research. Interestingly, other universities initiating undergraduate research programs begun by faculty and students had some of the early problems encountered in Caltech's SURF program.

Ten Caltech SURFers Attend Second Annual National Conference on Undergraduate Research

Ten Caltech SURFers attended the Second Annual National Conference on Undergraduate Research, hosted by the University of North Carolina at Asheville with travel funds primarily

from the NSF-REU grants awarded to Caltech. Each of the SURFers presented the results of his or her project and later expressed enthusiasm about the conference. The primary goal of this conference was to provide a forum for undergraduates to present the results of their research and scholarly activities in all fields of science, mathematics, engineering, humanities, and social sciences.

A second goal of the Asheville conference was to provide an opportunity for candid discussions regarding trends, problems, and opportunities in the education of undergraduates. These discussions involved students, faculty, administrators, and representatives of government agencies. Many people throughout the country expressed interest in Caltech's SURF program.

At Asheville, young scientists attended presentations such as "Terror in the Poetry of Robert Frost" and "Eisenhower's Warnings: the Context and Implications of the Military-Industrial Complex and Scientific-Technological Elite." On the other hand young humanists and social scientists attended sessions such as "An Expert Systems Model for Crisis Management in Cases of AIDS," "Was the Earth Ever a Snowball?," and "The Use of Computer Simulations in Teaching Elementary School Science."

The theme of the conference, "Building Bridges Through Undergraduate Research," was suggested by Fred Shair, who serves on the Executive Committee of the National Undergraduate Research Conference. Many college administrators now realize that some of the best ambassadors of their universities are their enthusiastic students who have conducted independent research. As noted by many of the speakers at this conference, undergraduates often enjoy building bridges within a university as well as bridges to the greater community. Some of the external bridges involve interacting with prospective freshmen students, prospective graduate students, alumni, trustees, and potential donors, and visiting corporations and other universities.

If through these conferences students, faculty, and administrators continue to build bridges and exchange ideas, the conferences could become an effective instrument in catalyzing constructive change in undergraduate curricula throughout the United States.

At the conference, the common stereotype of the researcher with a narrow view of the world was exploded by the broad interests displayed by student researchers. It is rather ironic that, as a group, young researchers appear to have *broader* interests than those who do not attempt to do independent scholarly activity. Inquisitive students undertaking an independent research project learn to be resourceful and imaginative, qualities that mold them into "self-educators" motivated for lifelong learning and growth. Attempting independent research early in one's life broadens one's perspective.

Looking Ahead

Several colleges and universities throughout the country, impressed with Caltech's program, are attempting to develop a network by which excellent students at one institution may spend a summer conducting research at another. Not only would this be of great value to the student, it could help the participating institutions recruit potential graduate students. Although the Caltech SURF program may not grow in size, it would be beneficial for the spectrum of opportunities to continue to increase. This spectrum could expand to include other universities, corporations, national laboratories, and opportunities overseas. Improving the opportunities for our students to grow professionally will benefit all.

Biology

Computer Modeling of the Stomatogastric Ganglion in *Panulirus Interruptus*

Munir Bhatti
Sponsor: James M. Bower

Among the delicacies of the California spiny lobster is its stomatogastric ganglion. The 30-neuron mass dictates internal grinding and other muscle-controlled aspects of the digestive system. Fourteen of these command the peristaltic transport of food through the pylorus. Even when stripped from the lobster and pinned onto a dissection tray, this small group continues to produce the correct firing pattern to run the pylorus. Since the output, synaptic connections, and cellular properties of this small circuit have been extensively researched, the ganglion is ripe for computer simulation to verify current concepts of neural circuit operation.

A Comparative Study Between Gap Junctions of the Mesozoan and More Complex Organisms

Sandip Biswal
Sponsor: Jean-Paul Revel

One approach to understanding the genesis of multicellularity is to examine the types of intercellular contacts which exist in organisms believed to be close to the base of the phylogenetic tree. In this project, we have used the Mesozoan, the most primitive organism of all extant today. We will attempt to establish a relationship between gap junctions from those of the Mesozoan to those of higher organisms (rat) through hybridization experiments (Northern Blots) using Mesozoan RNA against various rat liver and heart cDNA probes. Immunofluorescence microscopy will be used to detect basic structural components of the Mesozoan such as laminin, fibronectin, and collagen type IV and, ultimately, the Mesozoan gap junction protein. Also, Western Blot analysis of Mesozoan homogenate to determine whether antibodies to rat heart and liver gap junctions can bind to Mesozoan gap junctions. Studies such as these will help us determine whether gap junctions from different origins serve similar functions or evolve via functional specialization.

Contrast Sensitivity in Primate Visual Cortex

David Bourgeois and Johnny Ng
Sponsors: John M. Allman and Christof Koch

We developed a computer system for presenting visual stimuli to an awake monkey while recording the firing response of a single probed neuron in the visual cortex. The system allows us to vary contrast between stimulus and background, while modifying the shape, orientation, and direction of motion of the stimulus. Using this system, we hope to learn more about the architecture of the primate visual system.

Cellular Studies of Sea Urchin *Strongylocentrotus purpuratus*

John Bowers
Sponsors: Eric H. Davidson and Courtney Smith

The research was composed of four semi-independent projects involving culturing and characterization of sea urchin cells. The first project was an attempt to find the source of new coelomocytes in the adult sea urchin. It involved culturing parts of a sea urchin in artificial media and checking for coelomocyte production. This was compared to replenishment of coelomocytes in whole animals. Results suggest the source to be the tissue lining in the test wall. The second project involved a characterization of the surface of the coelomocytes with fluorescent lectins. Of ten lectins tested, wheat germ agglutinin and Ulex europenaus ll agglutinin were positive, each binding to different subpopulations of coelomocytes. The final two projects involved *in vitro* culturing of coelomocytes and sea urchin larval cells. No conclusive growth was seen in larval cells, because of technical problems. Coelomocytes failed to multiply but did form syncytia. Syncytia formation began within an hour, with coelomocytes mixed from different animals forming larger syncytia. Only one cell type appeared to be necessary for syncytia formation.

Testing Models of the Biophysical Mechanisms Underlying the Initiation of Long-Term Potentiation in the Mammalian Hippocampus Using Computer Simulations

Brian Brandt
Sponsor: Christof Koch

The dominant model describing the biochemical events leading to the expression of long-term potentiation (LTP) asserts that LTP is triggered by a rise in free intracellular calcium. To ascertain the intracellular conditions and presynaptic events leading to this rise in calcium concentration, two models were simulated on a SUN3 workstation. One previously developed model depicts a voltage-dependent but neurotransmitter-dependent channel activating a voltage-dependant calcium channel. The other model represents the combined voltage and neurotransmitter-dependant operation of an NMDA channel. Differences between these models were examined, suggesting biophysical experiments to distinguish between these models in the Ca I and Ca III regions of the mammalian hippocampus.

Glycogen Depletion Studies of Synapse Elimination

Eric Fung
Sponsor: David C. Van Essen

Elimination of synapses, leading to singly-innervated muscle fibers, is one of the major events in the development of the mammalian neuromuscular junction. Many studies of synapse elimination depend on examination of changes in motor unit size that occur due to synapse loss. Stimulation of individual motor units to deplete their muscle fibers of glycogen allows us to make precise quantitative measurements of the number of muscle fibers in a motor unit, their contractile type (fast or slow), and their size. This precision is important in allowing us to evaluate the accuracy of estimates of motor unit properties made in the past. For example, twitch tension measurements have been used to estimate both size and fiber type composition of motor units; we are able to use glycogen depletion to assess the accuracy of those estimates.

PCR Amplification of Gap Junction Genes

Milind Gangal
Sponsor: Jean-Paul Revel

Gap junctions are intercellular connections that allow small molecules to pass. Several genes that code for various gap junction proteins have been characterized. It is of interest to determine the pattern of gap junction gene expression in developing mammalian embryos. However, one of the cellular components used to measure gene expression, the nRNA, is present in levels too low to be detected by conventional means. We have attempted to solve this problem by using a method called the polymerase chain reaction (PCR), which is able to amplify DNA fragment 10^5 to 10^6 times. In order to detect nRNA, the RNA is first reverse transcribed to cDNA. It is then

converted to double stranded DNA and amplified using PCR. The amplified DNA fragment can then be separated on a polyacrylamide gel and detected by standard autoradiography. The sensitivity of this technique will allow us to follow gap junction gene expression during early mammalian development.

Deletion Mutants of Type II Ca^{2+}/Calmodulin-Dependent Protein Kinase

Laura J. Hernandez
Sponsor: Mary B. Kennedy

Type II Ca^{2+}/calmodulin-dependent protein kinase is an abundant enzyme found in the postsynaptic densities of many central nervous system synapses. It is a holoenzyme composed of twelve closely related 50,000 (α) and 60,000 (β) dalton subunits. These subunits contain a conserved kinase domain (amino acid residues 16—289 in α) followed by a calmodulin binding domain (290—314 in α) and a putative regulatory or binding domain (315—478 in α). As part of an ongoing study of the kinase's functional domains, three deletions mutants of the α subunit were constructed. The first two mutants are missing the regulatory domain and parts of the calmodulin binding domain. These constructs will be used to determine the function of different portions of the calmodulin binding domain. The third construct contains, in addition to the kinase domain and the calmodulin binding domain, the first 81 residues of the hypothesized regulatory or binding domain. It will be used in studies of holoenzyme formation.

Isolation of a Yeast Gene Defective in m-RNA Splicing

George Yen-Hsi Liu
Sponsor: John N. Abelson

In recent years, advances in the study of m-RNA splicing mechanism have come from the analysis of certain yeast mutations. To analyze these mutations, the defective genes first have to be generated, isolated, and sequenced. My project consists of isolating the minimum wild type DNA sequence needed to complement the defect. This is done by cutting a wild type genome into many small fragments and putting specific pieces back into the mutant to test for complementation. So far, I have isolated a 5Kb fragment containing the defective gene.

Nuclear Magnetic Resonance Imaging and Magnetization Transfer of Rabbit Muscle and Primate Brain

Bassem Mora
Sponsors: John M. Allman and Peter Barker

Nuclear Magnetic Resonance Imaging (NMRI) is by far the most powerful imaging technique in medicine today, resulting in a precise anatomical map of the living tissue being imaged. Nuclear Magnetic Resonance Magnetization Transfer (NMRMT) between phosphocreatine and ATP, on the other hand, generates accurate biochemical information regarding increases in local concentrations of ATP in the tissue. We have attempted combining both MRI and NMRMT to generate an *in vivo* physiological map of rabbit muscle and primate brain tissue superimposed on an anatomical map of the same tissue. This would result in the superposition of the functional data from NMRMT upon the anatomical image from NMRI, all attained solely employing Nuclear Magnetic Resonance. *In vivo* studies are still under way, and results will be available shortly.

Rat Visual Cortex: A Developmental Study

Thuy Nguyen
Sponsor: John M. Allman

One of the fundamental tasks of neurobiology is to understand the mechanism(s) underlying the development of mammalian cerebral cortex. We have employed immunological techniques to generate monoclonal antibodies against antigens important in the embryonic differentiation of rat cerebral cortex and important in the future specification of visual cortical areas. These antibodies may serve as biochemical probes in the study of the inside-out migration of cells during corticogenesis as well as for the later localization of these cells within specific layer/area/region boundaries. Because these antigens are conceivably quite rare, the immunosupression technique of Paul Patterson and Bill Matthew (1983) was employed to suppress the immune response to common brain antigens. Fetal rat tissue from frontal cortex (for suppression) and from posterior visual cortex (for immunization after suppression) was used for the experiment. Embryonic day 14 (gestation, 21 days) was chosen because that is the day when the first cortical layers 5 and 6 have just begun to differentiate and migrate toward the cortical surface. Positive antibodies will be characterized both biochemically with the immunodot method and histologically with cryostat sections of embryonic as well as adult rat.

Chemistry and Chemical Engineering

A Study of the Extra Loop in Recognition of a tRNA by Its Cognate Amino Acyl Synthetase

Teresa Ollick
Sponsor: John N. Abelson

To explore the possible role of the extra arm of a tRNA in recognition by its cognate amino acyl synthetase (AAS), two tRNAs (leucine and tyrosine) were constructed, each with a 5 base-pair extra arm rather than the usual 15 and 13 base-pairs, respectively. The tRNAs insert an amino acid in response to an amber stop codon, providing an effective way to monitor activity without altering tRNA-AAS interactions. Using a variety of cloning vectors in *E. coli* we have verified the accuracy of the constructions as well as their abilities to function as amber suppressors. Assays will be performed to determine the efficiency of amino acid insertion as well as the specificity of each tRNA.

The Search for a G-Protein Involved with Taste Signal Transduction

Samantha Seaward
Sponsor: Melvin I. Simon

The purpose of this project was to attempt to determine whether or not there is a G-protein specifically involved with taste signal transduction. This was accomplished by first preparing lambda bacteriophage DNA to construct a rat tongue library for screening. Next, mRNA was purified from rat brain, heart, lung, spleen, liver, intestine, muscle, testes, kidney, and tongue. The next step is to run the mRNA samples on a formaldehyde gel and run Northern blots to determine if tongue mRNAs code for more G-proteins than other non-sensory organs. Then it will be determined if there are G-proteins in tongue that are unique to that organ, and whether or not those proteins are involved in taste signal transduction.

Analysis of Site-Specific Mutations as Introduced into Defective Interfering Particles of *Sindbis* Virus

Chandra Tucker
Sponsors: James H. Strauss and Hubert G.M. Niesters

In studying the affect certain mutations have on a defective-interfering particle of the *Sindbis* virus, we cloned a KDI piece in M13-MP19 by cutting at the Sac 1 and Eco Rl sites and ligasing the pieces together. We then worked to induce mutations in this clone. A second approach to induce mutagenesis involved cutting the original KDl clone and inserting a 300bp containing the mutation.

Temperature-Sensitive *vpt* Mutants

Sang Su Yun
Sponsor: Scott D. Emr

Yeast vacuolar protein targeting (*vpt*) mutants are defective in protein targeting to the vacuole. Some *vpt* mutants are temperature sensitive for growth (*ts*). My project was to search through a bank of approximately 1000 random *ts* strains to find more *vpt*'s and to search for diploids that were *ts*, indicating that the new *ts* mutation did not complement the known *vpt* mutation—i.e. they are probably mutant at the same locus. To confirm this, tetrads from these *ts* diploids are being genetically analyzed. By microscopic examination, some *vpt* mutants have no vacuole. The new *ts* mutants were examined to see if they have a vacuole. So far I have found about 12 new mutants.

Observation of Particle-Bubble Interactions in Low Reynolds Number Flow

Elizabeth Andrews
Sponsor: L. Gary Leal

The study of the removal of small (30-50 micron) particles by tiny bubbles in low Reynolds number flow is important for many industrial and research processes. This SURF demonstrated that, using a fairly simple apparatus, it is possible to view quite clearly both the capture of a particle and subsequent trajectory followed by the particle-bubble unit. A lessening of optical "noise" and increase in picture clarity were achieved using a diffuse light source, while vibrations were nearly eliminated using a vibration damping table to mount the viewing apparatus.

Computing Long-Range Electron-Transfer Pathways in Metalloproteins

Jonathan Betts, Harvard University
Sponsor: Harry B. Gray

A computer program was written to find long-range electron-transfer pathways between proposed donor and acceptor atoms within proteins. The calculations considered through-space quantum-mechanical tunneling at up to 8 angstroms, along with routes through the hydrogen bonds located by the program, and the covalent bonds identified by x-ray crystallography. The predicted rates roughly matched experimentally determined rates. Refining this model will require adding molecular dynamics simulations.

Dependence of T_1 and T_2 Times of Water on Concentration and Environment

Leonard Chen
Sponsor: John D. Roberts

The technique of nuclear magnetic resonance imaging (NMRI) of the body uses three basic physical properties of materials that contain magnetic resonant nuclei (and with the human body this is mainly the protons of water in tissues, muscle, etc.): the T_1 relaxation rate constant (spin-lattice or longitudinal relaxation), the T_2 relaxation rate constant (spin-spin or transverse relaxation), and proton spectral density. Because approximately 70% of the human body is composed of water, water molecules are found in almost every tissue, bone, muscle, etc. and vary in concentrations and in chemistry because of local environments. For this reason, T_1 and T_2 times can vary from locale to locale. This project was concerned with defining conditions for a 90 MHz JEOL NMR spectrometer and a 500 MHz Bruker NMR spectrometer to measure the changes in T_1 and T_2 times due to different proton concentrations and environments. Experiments with differing concentrations of mixtures of D_2O and H_2O showed large changes in the T_1 and T_2 times for the protons. The water in gelatin samples of differing concentrations showed that the T_1 and T_2 times depend on the concentration, temperature, and state of the gel (i.e. ungelled, gelling, and gelled), and they changed, though not markedly, with changes in molecular correlation times as expected. Work with hollow polystyrene microspheres provided by the Rohm & Haas Company showed that the water contained inside the sphere has both a different relaxation time and a different chemical shift than the water outside. It is anticipated that analogous results will be obtained with water in hollow tubes, micrometers in diameter. Changes in the physical nature of the substance caused by diffusion effects are also expected to vary the relaxation times. It is possible that these results can help to formulate methods that will enhance and explain the contrast scales of NMR images.

Attempts at Cupration of Phenylacetoacetate Dianion

Alex Gilman
Sponsor: Andrew G. Myers

Attempts were made to prepare an organocopper reagent from the dianion of phenylacetoacetate by cation exchange, then add it to an activated acetylenic compound to yield a substituted allene. The reaction sequence, as per a reliable protocol developed for aliphatic esters of acetoacetate, yielded primarily a haloallene not incorporating the enolester moiety. Decomposition of the dianion seemed to be a likely reason for the lack of incorporation. Generation of the dianion was attempted at lowered temperatures. No significant decomposition was observed; neither was enolester incorporation, however. Deuteration studies of phenylacetoacetate at these lower temperatures indicated that the dianion was not being generated successfully.

Two-Dimensional NMR Structural Studies of a DNA Oligomer that Binds Hin Recombinase

Josh Kurutz
Sponsor: John H. Richards

The unusual structures of DNA regions that are bound by the protein Hin recombinase are believed to play a significant role in the binding specificity.

One binding site of 14 base pairs was studied using two-dimensional Nuclear Magnetic Resonance (NMR) spectroscopy. The synthetic DNA oligomer was purified using reverse phase and ion exchange High Performance Liquid Chromatography (HPLC). Nuclear Overhauser Effect (NOESY) and 2D correlated (COSY) spectra were taken. Spectra were examined qualitatively by hand and quantitatively by computer software. The 51-mer Hin recombinase binding domain was synthesized, and binding studies were conducted using gel filtration HPLC.

Proton Assignments of Crambin by Nuclear Magnetic Resonance

Ngocdiep T. Le
Sponsor: Frances H. Arnold

The proton assignments of crambin are partially completed by combining the two-dimensional NMR spectra of crambin with its structural information from crystallography. The main-chain-directed assignment strategy is adopted. Ambiguities are explained in terms of interproton distances and distance geometry calculations.

Mild Conditions for the Removal of Acid-Labile Protective Groups

Peter Lindstrom
Sponsor: Andrew G. Myers

In the final stages of the laboratory synthesis of complex organic compounds, one frequently removes molecular fragments known as protective groups, groups whose function is to stabilize otherwise highly reactive portions of the target structure. These deprotection steps are of critical importance in the execution of any synthetic plan. In the course of a synthesis of the antitumor antibiotic neocarzinostatin chromophore, we were unable to effect such a deprotection step by all known protocols. We, therefore, developed a new reaction sequence, one which employs hydrogen peroxide-trichloroacetic acid as a deprotecting reagent. We have found this reagent to be effective in the removal of a broad range of protective groups (those which are labile to acid) and, therefore, believe that this technology will be of value in chemical synthesis in general.

Bond Rotation of Succinic Acid Through Measurement of Hydrogen Coupling Constants

Eugene Lit
Sponsor: John D. Roberts

It has been previously found that there is a relationship between the rotational angle of succinic acid about the 2-3 carbon bond (Gil et al., 1982) and the pH of the succinic acid solution. Changes in this rotational angle reflect the coupling constants between a hydrogen on the 2 carbon, and a similar hydrogen on the 3 carbon as measured by NMR. The coupling differences seem to have been accurately determined in the pH regions of approximately less than 4 and greater than 6. In the area between these two pHs, however, large margins of error were reported by Gil. This difficulty was due to complications arising from the coupling of other hydrogens. It was the purpose of this research to resolve the problems associated with the determination of the couplings in this region, through stereospecific deuteration of the complicating hydrogens, and selective deuterium decoupling. In addition, various methods to improve peak resolution were attempted, both in the synthesis stage, and in the spectral acquisition and work-up stages.

Synthesis of Non-Aqueous Solvent-Stable Enzyme

Jeffrey Ma, University of California at Los Angeles
Sponsor: Frances H. Arnold

Crambin, a small non-aqueous solvent-stable protein, could acquire enzymatic properties upon addition of certain chelating molecules. We attempted to modify crambin by adding such groups as benzimidazole, pyridine, and acetic acid to the N-terminus nitrogen. Characterization by NMR has not been completed yet, but successful modification would result in crambin derivatives which could bind metals (e.g., copper, iron). This would indicate that crambin (and perhaps other proteins) might be further modified to act as an enzyme or a scavenger.

Characterization of the Transport and Dispersion of Emissions Released Within a Hazardous Waste Disposal Facility

Mark Ma
Sponsor: Fredrick H. Shair

Three full-scale atmospheric tracer experiments (using SF_6) were conducted in a university hazardous waste disposal facility in order to characterize several aspects of this facility's emissions. One test involved releasing the tracer in a chemical storage area to investigate ground level emissions from this source. Another test involved releasing the tracer into a fumehood-type facility where the liquids are containerized and the emission stack height is about 25 feet above ground level. The third experiment involved releasing the tracer from an incinerator stack 40 feet above ground level. The data from these three experiments were analyzed to determine the concentration levels of emissions to which persons working in the facility are exposed.

Synthesis and Characterization of Polyethylene Glycol Derivatives for Affinity Partitioning

Edward Naranjo
Sponsor: Frances H. Arnold

Seven polyethylene glycol (PEG) derivatives with metal binding sites were synthesized from technical grade PEG (Mr 8000). These PEG derivatives were characterized by thin layer chromatography and classical qualitative organic analysis. Determination of their partition coefficients and their stability constants reveals that such PEG derivatives remarkably increase the affinity of PEG to some proteins in an aqueous two-phase system. Further improvements on the ligands could lead to useful polymers especially suited for large scale affinity partitioning.

Oxygen Regulated Hemoglobin Expression

Karen Oegema
Sponsor: James E. Bailey

Molecular genetics techniques used to study the promoter region of a hemoglobin-like gene originally found in the bacteria *Vitreoscilla* and cloned into *E. coli*. Two approaches were taken: (1) 5′ and 3′ deletions were made to map the active region of the promoter. (2) Protein and operon fusions were made with the *E. coli* lac Z gene.

pH Dependence of Formal Potentials of Redox Couples Incorporated in Nafion Coatings on Electrodes

Matthew Tyler
Sponsor: Fred C. Anson

Two derivatives of 4-4'-bypyridine, N-methyl and N-ethanol were incorporated into Nafion coatings on electrodes. The pH dependence of the formal potential for each compound incorporated within Nafion was compared to the pH dependence at bare electrodes. It was found that while both compounds experienced a shift in pKa from solution to incorporation, the shift for the ethanol derivative was slightly larger than that of the methyl derivative. Also, the formal potential for pH less than pKa for the ethanol derivative was shifted more negative, whereas no significant shift was observed for the methyl derivative. These results confirm the structure of Nafion containing hydrophobic and hydrophilic regions.

Inside-Out Vesicles from Erythrocyte Membranes

Jennifer Wales, Amherst College
Sponsor: Sunney I. Chan

Techniques for the preparation and purification of inside-out vesicles from human erythrocytes were studied. Vesiculation was accomplished both with a needle and with a French press. Density gradient centrifugation was used to separate sealed from unsealed vesicles. A *Ricinus communis* agglutinin (RCA)-sepharose column was studied as a method for separating inside-out vesicles from right-side-out vesicles.

Studies in Molecular Recognition

Elizabeth A. Warner
Sponsor: Dennis A. Dougherty

The binding properties of a new class of anionic water-soluble macrocycles have been attributed to ion-dipole and (pi symbol)-stacking interactions. The development of a new generation of macrocycles with (cationic) quaternary ammonium salts as the water solubilizing functional groups will give valuable information about the impact of host charge on guest binding, as well as expand the pH at which binding studies may be conducted. The synthesis of a macrocycle with quaternary ammonium salts has been explored. In the course of these efforts, a novel method of aminolysis was implemented successfully.

Enhancing Nitrogen-15 Signals in NMR by the Nuclear Overhauser Effect

Alex Wei
Sponsor: John D. Roberts

Nitrogen-15 NMR spectroscopy has enormous potential in determining the conformation and structure of organic and biochemical compounds, but is hampered by its low natural abundance and weak magnetic dipole moment. The Nuclear Overhauser Effect (NOE) can in principle amplify the nitrogen signal by almost five times, but is dependent on the structure of the sample, its chemical environment, and available relaxation mechanisms. Because the lowering of relaxation times is also helpful in attaining a better signal, the use of paramagnetic relaxants and viscous solvents are common; their effect on the NOE is studied here.

Engineering and Applied Science

Reactivity of Bs-Zirconocenes

Cynthia Wittman
Sponsor: John E. Bercaw

Carbon bond activation by complexes containing the early, electron-deficient transition metals as centers is useful in the transformation of more abundant hydrocarbons into harder-to-obtain and/or more useful compounds. The traditional pentamethylcyclopentadienyl (Cp*) ligands of these metals' hydride and alkyl derivatives have a strong tendency to undergo intermolecular metallation, which, in many cases, can hinder or even block a desired catalytic conversion. As such, a metallation-resistant ligand, Bs (for bis-silicon; a bis[dimethylsilyl] bridged bis[cyclopentadienyl] structure) was synthesized. Compounds containing this ligand are also less sterically hindered than the corresponding Cp* compounds and are therefore expected to have enhanced selectivity in these conversions. The focus of this research has been to develop a synthesis of a catalytically useful zirconocene containing this ligand. The hydridochloride [BsZr(Cl)(H)] was synthesized, and its reactivity towards various olefins was tested, in order to ascertain the extent to which the dimerization, oligomerization and/or cyclization of these compounds was occurring.

Purification of Beta-Lactamase Using Fast Protein Liquid Chromotography

Scot Wolfe
Sponsor: John H. Richards

RTEM-1 beta-lactamase encoded by the plasmid pBR322 was purified from the periplasmic space of *Escherichia coli* using fast protein liquid chromatography (LKB). Periplasmic proteins were fractionated by first using an ion exchange column (Pharmacia Mono-Q) utilizing a non-linear sodium chloride gradient. A gel filtration column (Pharmacia Superose 12) was used to separate beta-lactamase from the remaining impurities. SDS-PAGE revealed only one minor impurity of molecular weight between 3000 and 8000 daltons. Further study using a non-denaturing gel revealed only one protein band, suggesting that beta-lactamase may have the ability to selectively bind this small peptide.

Computer Graphics Display of Simple Molecular Systems

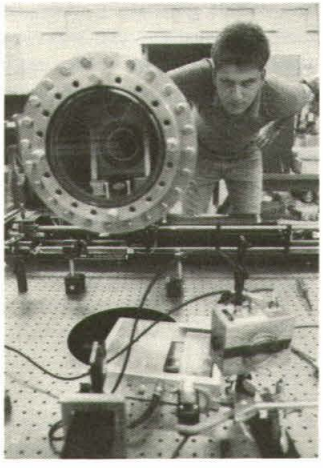
Harold Zatz
Sponsor: William A. Goddard III

Modern quantum mechanical methods can generate numerically exact solutions of Schrodinger's equation for the electrons of simple molecules. Using this electronic information, this project renders molecules via both wire-frame contour drawings and full electronic renderings using a modified VBUFFER algorithm. A new algorithm for generating an n-dimensional isovalue contour of a scalar field is also discussed.

Ball Milling and Shock Wave Consolidation of Amorphous Metals

Amin Abid
Sponsor: Brent T. Fultz

The purpose of this project was to produce large bulk samples of amorphous metals by shock wave consolidation of amorphous metal powder. Amorphous metals are commercially prepared in the form of thin ribbons by rapid quenching, but thick samples cannot be made in this way. We obtained commercial amorphous metal ribbon and prepared it in powder form by ball milling. This powder was verified to be amorphous, and was then consolidated into bulk form by impacting it with a high velocity flyer plate from a 35mm smooth-bore propellant gun. I was successful in consolidating powder of 100-170 mesh with 259KJ/g kinetic energy per mass into amorphous bulk samples that had only 1% porosity. Typical materials characterizations were carried out on the bulk samples, and were compared with those of the original commercial ribbon.



Sequence Determination of a Gene for Methanol Dehydrogenase

Marcus Averbach, University of California at Berkeley
Sponsor: Mary E. Lidstrom

To compare the regulatory mechanisms of the MOX A1, MOX A2, and MOX A3 genes of Methylobacterium AM1 to those of other genes, the nucleotide sequence of these three genes must be known. From the nucleotide sequence, the composition of the three polypeptides encoded by the genes can be determined, along with the promoter regions which regulate transcription of the genes. So far, all of the 900 base MOX A1 gene has been sequenced, as well as 710 bases of the 1.4 kB MOX A2 gene and 625 bases of the 1.5 fkB MOX A3 gene.

Computation of Flow Over a Plate

Thomas R. Bewley
Sponsor: Anthony Leonard

A vortex blob tracing algorithm developed by Kiat Chua, a Caltech graduate student, was modified to compute flow over a thin, flat plate at an angle of attack and also to compute flow over a plate undergoing a specified oscillation about the midpoint or the quarter chord. Separation of the flow was only considered from the ends of the plate, which caused problems in some runs. Much time was spent in the effective presentation of results, including a "movie" showing the history of the flows, and noting effects that could also be seen in nature, in addition to effects that could not.

Isolation of Iron Reduction Mutants in Alteromonas Putrefaciens 200

Lindsey N. Dubb
Sponsor: Mary E. Lidstrom

Alteromonas putrefaciens 200 (AP200) reduces iron at a rate much greater than that witnessed in any other microorganism. It is the purpose of this project to complete the preparatory steps toward the understanding of this extremely fast iron reduction mechanism. This entails the mutagenesis and screening of AP200 colonies to obtain iron reduction mutants, the testing of the iron reduction rates of these mutants, and the preparation for plasmid insertion, which will be done after the summer ends.

The Eigenstates of Electrons in Quantum Wells

Kin Ha
Sponsor: Kerry J. Vahala

This project is a theoretical investigation of the electronic eigenstates in man-made structures called quantum wells. The approach we use is as follows: We first solve the electronic eigenstates for a bulk crystal by the K.P method, and then employ the Envelope approximation to solve for the eigenstates of a quantum well. We begin with a two-band model (valence and conducting), and then extend it to a four-band model (conducting, light-hole, heavy-hole, and split-off). This model should enable us to predict the electronic properties of a semiconductor-quantum-well laser. Our numerical results will be for a GaAs-AlGaAs system.

Finite Chemical Kinetics Analysis for Supersonic/ Hypersonic Combustion

Alvin W. Law
Sponsor: Paul E. Dimotakis

A simple flow/thermodynamic model, proposed by Professor Paul Dimotakis and Jeffery Hall (1987), is used as a hypothetical hypersonic jet engine to examine its subsequent aerodynamic/thermodynamic/chemical kinetic properties. Sample calculations and comparisons for different chemical systems are described for a set of initial flow and thermodynamic conditions of the reactants involved.

Amorphization of $ErFe_2$

Howard Lee
Sponsor: William L. Johnson

Amorphous $ErFe_2$ can be prepared from crystalline starting materials by several different methods, such as absorption of hydrogen and mechanical deformation in a ball mill. Hydrogen-induced amorphization of $ErFe_2$ occurs by a distortion of the lattice due to the presence of hydrogen atoms in certain interstitial sites. The amorphous phase can also be obtained by ball milling of the elemental powders in the composition of $ErFe_2$. This process occurs by the diffusion of the smaller Fe atoms into the Er grains.

Dielectric Waveguide: Nonlinear Medium Construction and Characterization

Charles Su-Chang Tsai
Sponsor: William B. Bridges

Nonlinearity was introduced into round and square dielectric waveguides of various K by a weakly coupled system of diodes. Diodes placed as dipole antennas within the waveguide resulted in the best coupling for the HE11 mode. Second harmonic was observed at ~ -36 dBm when incident power is ~ 0 dBm ($>0.02\%$ power conversion efficiency). The efficiency of harmonic generation should improve with increased incident power and high performance, low-threshold diodes. Propagation constants and second harmonic matching conditions for the HE11 mode was obtained by solving the characteristic equation for a two region round waveguide. With periodic diode structures, harmonic generation was frequency dependent.

Segmented Wave Generator

Jeff Willis
Sponsor: Fredric Raichlen

The purpose of this project was to complete the preliminary design of a machine capable of generating three-dimensional waves and waves at an angle. Many possible options were considered in order to find an innovative system that would be superior to those currently in use. It was concluded that a hinged-sliding mechanism with a flexible teflon seal would be most suitable. A mock-up of a single segment was constructed to test for smoothness of motion and for buckling of the teflon seal.

Computer Simulation of Particle Size Distribution Evolution in Thin Films

Chih M. Yang
Sponsor: Harry A. Atwater

Evolution of size distribution for coplanar spherical caps growing on thin films is obtained by computer simulation. Given a size distribution function $f(4,t=0)$, the simulation calculates $f(r,t)$. The simulation allows for the effects of ion bombardment, sputtering, and deposition on particle growth.

Wave Energy Absorption Study

Chen Yuan
Sponsor: Fredric Raichlen

In order to protect those earth features, such as cliffs and seashore, engineers normally build stone embankments to protect them from ocean wave erosion. My research this summer is to study the energy dissipation characteristics of those stone embankments, and determine the wave energy absorption as a function of incident wave parameter and stone embankment geometry. The incident wave parameters are wavelength and wave height. The stone embankment parameters are embankment height, front face absorber slope and stone size. I am doing this research in a wave flume 15 m long and 40 cm wide and can only run solitary and conoidal waves. I will discuss those waves in my final report.

Geological and Planetary Sciences

OH UV Spectrum and its Application to Atmospheric Measurements

Yuk Lung Ha
Sponsor: Yuk L. Yung

OH is an important molecule in tropospheric chemistry and cometary atmospheres, and is involved in the ozone catalytic chemistry in the stratosphere. Dr. Stanley Sander (JPL) has been developing a Fourier Transform Ultraviolet Spectrometer, which can detect OH transitions. The OH UV spectrum in the terrestrial atmosphere has been synthesized, and other spectroscopic quantities have been calculated. The results will be used to retrieve OH abundances from Dr. Sander's observations.

Mesospheric $O_2(^1\Delta_g)$ Nightglow Emissions

Collin Howell
Sponsor: Yuk L. Yung

We have modeled possible production scenarios for the 1.27 μm $O_2(^1\Delta_g)$ nightglow from 80 to 100 km and compared the model results with data obtained by the Solar Mesosphere Explorer (SME) satellite at 3 A.M. local time. These comparisons indicate that two reasonable $O_2(^1\Delta_g)$ production scenarios can explain the data. Both scenarios consider pumping of O_2 by excited OH (itself generated by the reaction $H + O_3 \rightarrow OH^* + O_2$) to be dominant below 94 km; the first scenario uses the reaction $O + O + M \rightarrow O_2(^1\Delta_g) + M$ to explain emissions above 94 km, while the second scenario uses $O + OH^* \rightarrow O_2(^1\Delta_g) + H$ to explain these emissions (the OH* in the latter case is again generated by $H + O_3 \rightarrow OH^* + O_2$). The chemiluminescent reactions present in the $O_2(^1\Delta_g)$ nightglow are unimportant in the $O_2(^1\Delta_g)$ dayglow: calculations show that they can produce no more than 2.5% of the observed $O_2(^1\Delta_g)$ emission between 80 and 100 km at 3 P.M.

Development of Observational and Culturing Techniques with Magnetotactic Bacteria

Ralph Shih-Ying Lin
Sponsor: Joseph L. Kirschvink

Finding environments where magnetotactic bacteria are abundant, ascertaining the nature of bacterial magnetotaxis, and growing them in pure culture are the aims of this project. Field trips to potentially rich sources of magnetotactic bacteria were undertaken. Bottom sediment samples were obtained and subsequently tested for presence of the bacteria. An orthogonal Helmholtz coil system was constructed to develop an efficient means of counting bacteria. In addition a pulse-remagnetizing coil system was developed for coercivity threshold measurements of a sample population. This setup can be utilized to separate a population based on their magnetic properties. It has been known that introducing a magnetic pulse antiparallel to the magnetic orientation of a given population can remagnetize north-seeking bacteria into south-seeking. Using this basic principle we can introduce two consecutive pulses of different magnetic strengths to separate the bacteria into two groups defined by a given coercive range. Cultures under a variety of media conditions were made for aquaspirillum magnetotacticum (MS1). The various cultures consist of modified versions of two basic media: a BSKII medium and a methanogen medium. Varying oxygen tensions, concentrations of reducing agents, and physical forms of the media include some of the variables integrated into the cultures.

Magnetostratigraphy of the Mid-Pliocene Pico Formation

Dave Long
Sponsor: Joseph L. Kirschvink

The Pico Formation is composed of marine sediment deposited at 270-600 meters depth in the Ventura Basin during the mid-Pliocene, about 3.5 million years ago. Most of the sedimentation is in the form of turbidites, distinct bedding units resulting from the intermittent flow of debris down the slopes of marine terraces. In being uplifted to its current position on the northern flank of the Ventura Syncline, the beds of the Pico Formation have turned so they are dipping at 70 degrees from the horizontal, and consequently the creek which runs north of Santa Paula cuts through the beds nearly normal to the bedding planes, providing good exposure for about 800 meters of section. Although use of a superconducting magnetometer allows measurement of the weak magnetic fields typical of sediments, a common problem in sediment magnetostratigraphy is the possibility of events after deposition altering the initial paleomagnetic direction. Not only is the circular standard deviation of pole directions around 5 degrees, but both the presence of a strong secular variation waveform and paleolatitude errors of under 5 degrees are indicative of the high fidelity of the Pico Formation. A remarkably high calculated deposition rate of 85 cm/1000 years allows high-resolution studies of the reversals of the geomagnetic field. The initial survey of 800 meters of section places this section with its base at the start of the Cochiti Event in the Gilbert Reversed Epoch, extending from 3.9 to 3.2 million years ago. Four reversals have been found during this period, allowing examination of both normal to reversed and reversed to normal transitions. Three of these reversals have been located with 1200-year-interval samples, and the resolution can be improved an order of magnitude for a detailed study of field behavior during transitions.

Origin of the Moon: Formation and Aggregation of Protomoons From a Circumterrestrial Disk

Dan Mahoney
Sponsor: David J. Stevenson

The currently favored theory of lunar origin is that a Mars-sized projectile collided with a molten earth. This impact ejected liquid and vapor material into an earth orbit, where a disk of the material was formed. As the disk spread outward, it reached a critical surface density where it started to break up and formed protomoons in a region of approximately three to ten earth radii. We studied the orbital evolution and growth rate of these protomoons, and determined that eventually a moon-sized body will result and spread out in an earth orbit.

Visual Display of Quantitative Information

Allen Price
Sponsor: Andrew P. Ingersoll

Using the IRIS graphics system, I was able to develop software which transforms the time-dependent numerical output of a Jovian atmospheric model into useful animations. Vorticity and pressure are represented by color intensities while velocity is represented through the advection of particles on the screen. By experimenting with parameters such as the color scheme, time intervals between successive frames, and the particles' characteristics, I sought not only to display the data as accurately as possible, but also to represent them in a way which would facilitate the human eye's recognition of general patterns, patterns that would be difficult to read in the "numbers" alone.

The Role of Large Infrequent Impacts in the Thermal State of the Primordial Earth

Danny Rintoul
Sponsor: David J. Stevenson

This project consisted of, first, a theoretical model of the heating of large bodies by impacts, and second, a computer simulation of the evolution of the Earth by discrete impacts. Using this model as a tool, the thermal history of the early Earth is explored for different mass distributions of the incoming projectiles, along with changes caused by varying other parameters.

Far-Infrared Laser Spectroscopy

David Risher
Sponsor: Geoffrey A. Blake

A tunable far-infrared (FIR) laser spectrometer has been constructed to be used for FIR spectroscopy of Van der Waals and hydrogen bonded clusters in a supersonic jet. The output of a CO_2 laser is used to stimulate a gaseous molecule into an excited vibrational state, which then lases at a fixed frequency between two adjacent rotational levels. The FIR laser is then mixed with a 0.01-20 GHz microwave source, supplemented by frequency multipliers and amplifiers, in a GaAs Shottky barrier diode to produce tunable laser sidebands at $+/- 0.01-80$ GHz from the FIR laser output.

Humanities and Social Sciences

Modeling Diffusivity and Viscosity in Jupiter's Great Red Spot

M. Alex Santoso
Sponsor: Andrew P. Ingersoll

Tim Dowling, a Caltech graduate student, has made a hydrodynamic, numerical model of Jupiter's Great Red Spot. He wrote it as a FORTRAN program on a VAX minicomputer. But the model didn't model diffusivity and viscosity effects; it conserves energy. This summer I modified the program to include diffusivity and viscous effects in the GRS (Great Red Spot) model. In particular, stress-related viscous forces and some negative-viscosity forces were modeled. Preliminary runs on the VAX look a lot like the real thing. The original program, starting from zonally parallel flow, already generates vortices that merge into a single great vortex (the GRS), but then most of the energy is concentrated in the vortex, thus weakening the zonal flow around it, which is not very realistic. We hope that by mixing energy sources and sinks modeled by the modified program we can get more realistic results (a great vortex with strong zonal flow).

Earth's Atmosphere 800 Million Years Ago

Dawn Sumner
Sponsor: Yuk L. Yung

The earth's climate has fluctuated throughout its history. This is especially true for the period 1000-600 million years ago (Ma). A world-wide glaciation occurred at 800 Ma. What caused the earth to become so cold and then to warm to temperatures greater than those today? Albedo, atmospheric composition, and solar luminosity effects were studied using a radiative transfer model for the earth's atmospheric temperature profile in an attempt to understand climatic changes.

Crinoline: Fashion Un-Fickled

Heidi Anderson
Sponsor: Eleanor M. Searle

The Victorian hoopskirt, satirized, criticized, and often severely condemned in its heyday and wondered at in ours, is an example of the balance that all fashions must attain between technology, industry, and popular aesthetics. With this understanding, the crinoline is seen no longer as a quaint relic of an elegant age. It is a real garment, the result of a process of mass production and marketing which sprouted in the Industrial Revolution and continues to determine fashions today.

Differential Demography in Rural Liaoning 1774-1873

Cameron Campbell
Sponsor: James Z. Lee

Our study of 12,000 Chinese peasants who lived in Northeast China between 1774 and 1873 focuses on the relationships between household context and demographic processes. In part one, we analyze how changes in the rules of household formation during this period resulted in fundamental changes in household composition. In part two, we identify the emergence of a new disadvantaged group of kin relations as a consequence of these changes in household formation. Finally, in part three, we demonstrate that these changes in relative advantages are reflected even in such basic demographic processes as nuptuality, fertility, and mortality.

Prometheus and Faust: The Utilitarian Support of Basic Research in Science and Engineering

Hasok Chang
Sponsors: Thomas E. Everhart and Bruce E. Cain

There is an inherent tension in the support of basic research by utilitarian sponsors. A compromise between researchers and sponsors is worked out in the form of "control-research," aimed at the manipulation of nature, not directly connected to social utility or meaningful understanding. Recently there has been a strong growth of control-research fields in the United States; its influence is also manifested in the prediction-oriented philosophy of science and the value-free philosophy of technology. Control-research is essential for an effective utilization of scientific knowledge; however, it also results in the dissociation of social responsibility from research.

Science Bestsellers: Analysis of Success Factors and Related Issues

Sayuri Desai
Sponsor: John A. Sutherland

Best selling books communicate knowledge to the public on a multitude of subjects ranging from nutrition to psychology, but books about hard sciences such as physics are severely under-represented in the best-selling marketplace. In the past fifteen years, the *Publisher's Weekly* top ten weekly bestseller lists have yielded only eleven titles of a scientific nature. Six representatives of those recent science bestsellers, with accompanying data from publishing houses and other sources, were studied in detail with the aim of discovering why those books sold so well to a non-scientifically oriented public. Additionally, such thought-provoking issues as the validity of science simplified for the layman were explored.

Demographic and Political Characterization of Reagan Democrats

Samuel H. Dinkin
Sponsor: Bruce E. Cain

The majority of Californians are Democrats, but Ronald Reagan won the state in 1984. Reagan Democrats comprise most of the swing voters. From *Los Angeles Times* pre-and post-primary polls and county and city level aggregate data, Reagan Democrats can be characterized as more likely to be white, middle-aged, and middle income than other voters. They are less often college-educated and more often Catholic and blue collar than the rest of the electorate. They also tend to be economic and social protectionists, but they are less active in politics than either loyal Democrats or Republicans. However, the next President of the United States still must win a majority of the swing voters.

Development of Critical Thinking

Lisa Giaimo
Sponsor: Lee F. Browne

This research was concerned with the analytic abilities of children and the possibility of influencing their development. A series of tests were given to small groups of children in New Zealand, with individual attention given to any reading difficulties. Each test was followed by group discussion to improve the students' problem-solving skills. The format of each test was different, in order to introduce flexibility, rather than to cement specific test-taking abilities. These students were finally tested against an equivalent control group to assess whether any acceleration of analytic development occurred.

Correlations of Age, Prejudice, and Development

Susan Howard
Sponsor: Louis Breger

The thinking of some individuals is affected by their membership in a group which encounters prejudice in today's society. I used surveys completed by Black, Hispanic, Asian, Jewish, and Native Americans to determine how children growing up in one of these groups are affected by experiences of prejudice at various ages. I also studied the impact of parental attitudes and warnings regarding the possibility of unfair treatment, and the effects of various activistic and social support or discussion. Results from different generations, geographical regions, and racial/ethnic groups are also compared.

Effect of Information on Market Equilibria

Mitch Loescher
Sponsor: Charles R. Plott

My research consists of two major parts. The first is the design and production of an instructional videotape that shows subjects how to use the economics experiment software and explains some of the needed concepts. The second part is an investigation into how knowledge of market conditions affects the way subjects behave under varying market conditions. I edited the videotape at JPL's TV studio. The experiments in my investigation were conducted in the economics lab on campus with SSSP high school students and Caltech undergrads.

State and Federal Linkages in Tax Compliance

Michael McDonald
Sponsor: Louis L. Wilde

One of the issues of the 1988 presidential campaign is the raising of

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more revenues by the federal government. Since increasing taxes is unpopular with voters, another method has been discussed—the increasing of compliance with existing tax laws. Some estimates place the amount of uncollected tax as high as $90 billion a year. My project models the connections between federal and state auditing efforts and takes a look at a special topic—the effects of tax amnesties on tax collections.

On the Eighteenth Century Crimes in China

Xiaojian Yan
Sponsor: James Z. Lee

In Qing, China, there existed in the eighteenth century an elaborate review and appellate system. All the capital crimes were dealt with through this system. The detailed description of each capital crime was recorded clearly in the report to the emperors. From the detailed description, we studied the pattern of criminality as well as the tension and affect in families and in society. There was a sharp division between criminals' sex and victims' sex. Female criminals usually committed premeditated murder to kill their husbands and their husbands' lovers under the circumstance of adultery. Men, in contrast, usually fought over property. Tension in family was between brothers, between uncle and nephew, and between husband and wife. Affect was between father and son. In society, tension was between neighbors. Affect between men was friends, between man and woman was lovers. There was also tension between and within social groups. The pattern of criminality reveals the feature of the birth of capitalism, "Zhi Ben Zhu Yi Meng Ya."

Analysis of Optical Spectra of a Complete Sample of Bright Infrared Galaxies

Sean Ahern
Sponsor: David B. Sanders

The IRAS (Infrared Astronomy Satellite) Bright Galaxy Survey represents the first all sky census of extragalactic infrared emission at wavelengths between 10 and 100 microns, i.e., the thermal infrared. In addition to detecting copious infrared emission from optically catalogued galaxies, an unexpected result was the discovery of a class of galaxies with infrared luminosity equivalent to that of optical quasars. Analysis of optical emission line strengths using spectroscopic data obtained with the Palomar 200-inch telescope shows that the majority of infrared galaxies are powered by star formation. However, at the highest luminosities the primary energy source clearly seems to be a nonthermal active nucleus, presumably an infrared quasar.

Microwave Brightness Temperatures of the Center of the Quiet Solar Dish

Brandon Max Baumert
Sponsor: Gordon J. Hurford

Data collected during the last Solar Minimum were analyzed to obtain preliminary values for the central solar brightness temperature at twenty wavelengths ranging from 1.7 to 21 cm. Calibration was achieved by assuming a set of lunar brightness temperatures and multiplying these by the measured solar-lunar emission ratios. Data collected while residual solar activity was present were eliminated. Analysis of the effects of the antenna beam shape at the relevant frequencies was begun. Also, north-south, east-west, and circumferential profiles of the solar corona during the observations were collated.

The Liquid Argon Ionization Detector

Oren Bergman
Sponsor: David G. Hitlin

The theory of total energy particle detectors and how it applies to the Liquid Argon (LA) ionization detector is described. A simple one-stage model of the LA detector was studied. The various components of the detector system, including the vacuum system, the argon liquification system, the electronics and the detector itself are described in detail. The model was used to detect 364 keV electrons emitted by Sn(113). From this measurement the efficiency of the detector and the purity of the argon were calculated.

Far Infrared Emission from Giant Molecular Clouds in the Galaxy

Lisa Boehmer, Harvard University
Sponsor: Nick Z. Scoville

Virtually all star formation in galaxies is thought to take place in clouds of molecular gas. Young stars that have formed in these clouds cause them to shine brightly at infrared wavelengths. There has been some debate over whether the infrared luminosity of molecular clouds is due to nearby stars heating the clouds externally, or to embedded young stars using the CO rotational transition at 2.6 mm. In the immediate vicinity of young, high-mass, luminous stars the IR emission increases by a factor of 10. However, the IR surface brightness of a cloud seems to be constant over its surface, even in areas where the column of molecular gas decreases by a factor of 3 to 5, as indicated by the CO emission. A possible interpretation for this surprising independence of CO and IR emission is that giant molecular clouds are heated entirely on their surfaces by stars outside the clouds, or, less likely, that they are heated by an extremely uniform distribution of stars inside the clouds.

Numerical Modeling of Flows Associated with Liquid Targets in High Energy Physics Experiments

Paul Brewer
Sponsors: Robert D. McKeown and Douglas H. Beck

Density and temperature fluctuations in new particle accelerator targets involving refrigerated supercool fluids significantly affect cross-sections and other experiment design criteria. A finite element analysis of static and forced flow targets performed on the SDSC CRAY using FIDAP revealed preliminary quantitative results for the forced flow target and better understanding of both targets. The analysis proved of sufficient complexity to strain limitations of modern supercomputer capabilities.

Study of the Detector for MACRO

Yong Song Chu
Sponsor: Barry C. Barish

The comparison of the performance of the Hamamatsu and EMI phototubes was made. The comparison was based on their gain, afterpulsing, prepulsing, and single photoelectron efficiency. Light output vs. scintillator concentration with the Hamamatsu tube was investigated. Also light output was studied as a function of various locations in the scintillation tank.

Monte Carlo Simulation of Quasielastic Electron-Nucleon Scattering Inside a Nucleus

Donald Finnell
Sponsor: Bradley W. Filippone

In this SURF, a program was developed to simulate the final-state interactions of a quasielastically scattered nucleon with other nucleons inside the nucleus. Such interactions were treated in the impulse approximation, with an option for varying the nucleon-nucleon cross sections. Such simulations should help in interpreting the results of a proposed experiment which would use such interactions to look for evidence of color transparency.

Some Combinatorial Aspects of Pretzel Solitaire

Earl Hubbell
Sponsor: Richard M. Wilson

Pretzel solitaire is a mathematically interesting game because of its property of having total information available at the start of the game. The maximum number of moves in a game with n cards in a suit and m suits is demonstrated to be asymptotic to $(mn^2)/2$. Through Monte Carlo simulation the probability of winning a game appears to decrease exponentially with the number of cards in a suit, in contradiction to an observation of N. G. de Bruijn.

In Search of the Ultraluminous Galaxies

Jun-Young Jeon
Sponsor: B. Thomas Soifer

My objective was to locate the "ultraluminous" galaxies that are theorized to be in the process of turning into quasars. I was given about 1000 sources that were picked out based on the criterion of $\{0.2 < [(\text{flux density at } 25 \text{ um})/(\text{flux density at } 60 \text{ um})] < 1\}$. This criterion was designed to screen

out the stars and the less "luminous" galaxies. During the summer, I was able to identify about half of the sources and took the photographs from the Palomar and/or the ESO plates. In the process, I found out that 10 to 15 percent of all the sources might be "ultraluminous." I located at least one source that is definitely "ultraluminous" in the infrared region of the spectrum.

Models for Superluminal Radio Sources

Nikolaos Kidonakis
Sponsor: E. Sterl Phinney

Superluminal radio sources contain knots of radio emission which have been observed to travel across the sky at apparent speeds exceeding that of light. My project was to develop models that explain superluminal motion, while being consistent with the special theory of relativity and observations. My models included sources moving in a circle at an arbitrary angle to the line of sight, sources moving outward in cones of various half-angles, and shockwaves. The models were tried for both optically thick and thin sources. The emissions from patterns moving at nearly the speed of light were shown to produce apparent superluminal motion because of travel time delays. The brightness distributions of the models were calculated taking into account the relativistic beaming effect. It was shown for sources with many moving elements that we preferentially observe those moving close to the line of sight. For several models we calculated the probability of observing all the elements moving into the side containing the projected axis of the source, in order to account for the one-sided motion that is a characteristic of all observed radio knots.

Our Sun: Its Past and Future

Kathleen Kraemer
Sponsor: I-Juliana Sackmann

We have computed thousands of models in order to investigate the possibility that the sun was considerably more massive in the past. Our work shows that the sun may have had 20-80% more mass, which is consistent with all of today's key observations. Solar neutrino fluxes, initial helium content, surface lithium, and various isotope abundances were calculated as well. We also determined when the sun will significantly increase its surface luminosity, and at what point its radius will expand out to the different planetary positions, including that of the Earth.

Data Veto Histogram (DVH) Module for High Speed Readout of the L3 Electromagnetic Calorimeter

Amit Lal
Sponsor: Harvey B. Newman

The L3 experiment at LEP (Geneva, Switzerland) has uniquely high precision for the measurement of electrons, photons and muons, along with jets of hadrons, which are produced in high energy e^+e^- collisions. The calorimeter, consisting of 11,000 Bismuth Germanate (BGO) crystals, is calibrated using radiated photons from a Radio Frequency Quadropole (RFQ) accelerator. Histogramming and analysis of the spectra with conventional computer software has proven to be too slow during calibration when data flow is massive. Therefore, we designed the DVH module. Consisting of two VME cards, it will improve the speed by four orders of magnitude over a VAX 8800 CPU. The DVH module implements the necessary algorithms in digital hardware using pipelining, specialized memory structures, and fast control logic. Each module will handle the data from 1,000 crystals, and will process one event's data in less than a millisecond.

Effect of Scattering on the Variability of Astrophysical Sources

Andrew Lee
Sponsor: E. Sterl Phinney

We derive analytic solutions to the radiative diffusion equation for the case of pure Compton scattering. We consider the cases of a time-varying isotropic source at the center of a uniform spherical cloud and a spherically symmetric cloud with an inverse-square density variation, and of a time-varying pencil beam source in a uniform spherical cloud. We calculate the time variability at the surface of the clouds and compare these with the results of Monte Carlo simulations of photon scattering in these systems. These results have relevance to emission by accreting neutron stars in X-ray binaries and by nuclei of active galaxies.

Phase TV: Wavefront Analysis of an Optical Resonator

Brian Lemoff
Sponsor: Ronald W.P. Drever

In the Caltech gravity wave detector, a laser beam resonates in two high finesse forty-meter optical cavities, as well as a smaller, lower-finesse mode-cleaning cavity. To diagnose errors in alignment of the mirrors, as well as poor mode matching of the incident beam, it is useful to look at the phase front of the back-reflected spot. My project was to design and build a "phase camera" which would scan the spot and produce pictures of both phase and intensity on a color video display.

Random Matrix Theory and Its Relation to Properties of Physical Systems

Thomas Lenosky
Sponsor: Mark B. Wise

Attempts were made to generalize previous results on the two-point spectral correlation of general ergodic Hamiltonian systems in the semiclassical domain to describe higher order correlations, in order to establish agreement with random matrix theory predictions. In addition, the applicability of the Porter-Thomas (PT) distribution of reduced level widths was studied. An expression was derived for eigenvector density in a perturbed matrix ensemble. Tentative conclusions were reached about the universality of PT eigenvector statistics.

Correlation Functions in Spatiotemporal Chaos

Russell J. May
Sponsor: Michael C. Cross

This paper discusses the spatiotemporal correlation functions of chaoticallydynamic, coupled lattices. Various maps are employed for examining the dynamics, including the standard logistic map and a map which exhibits a conserved quantity. Graphs of the correlation functions with various non-linearity and coupling parameters are studied in position-time space as well as wavenumber-frequency space. The decay rate of the correlations of a given map are then compared to the decay rate of a similar map which exhibits a conserved quantity.

The Exciton Mediated Pairing Mechanism of Superconductivity of Copper Oxide Layers

Jeffrey Hung-Phi Nguyen
Sponsor: Robert M. Housley

A hypothetical model of planar superconductivity is constructed. The model consists of a slightly puckered, square planar Cu-O sheet, and an out-of-plane oxygen bonded to the Cu d_{z^2} orbital. The exciton system is localized on the Cu d_{z^2} orbital, and the conduction electrons lie in the plane. Electron-exiton interaction, between the in-plane electrons and the exciton, provides a pairing mechanism that could lead to high critical transition temperature for the copper-ioxide superconductor.

Coloring of Graphs and Hypergraphs

Satomi Okazaki
Sponsor: Richard M. Wilson

Problems concerning the coloring of edges of graphs and hypergraphs were studied. Several proofs of König's theorem are discussed. König's theorem states that, for a bipartite graph, $\nu = \tau$ (ν and τ respectively denote maximum number of disjoint edges and minimum number of vertices required to cover all edges). Generalizations of König's and Vizing's theorems are surveyed for both graphs and hypergraphs. For example, a conjecture of Erdös and Lovàsz, which is a generalization of König's theorem, is investigated. The conjecture is that for k-partite hypergraphs, $\tau \leq (k-1)\nu$. A k-partite hypergraph is constructed of hyperedges, each of which consists of exactly one vertex from each of k disjoint subsets of vertices (no two vertices within a subset are connected by a hyperedge).

A Study of the Pulse Shape Discrimination and Other Properties of a Low Background Neutrino Detector

Steven Olafson
Sponsor: Felix H. Boehm

A preliminary study is made into the design and feasibility of a proposed thousand-ton detector using liquid scintillator. As part of a search for neutrino oscillations, anti-electron-neutrinos from a reactor will collide with protons in the detector liquid to yield positrons and low energy neutrons. These resultant particles will cause the scintillator to emit light pulses, which are read out through photomultiplier tubes. Characteristics of several liquids are studied. To distinguish positrons and neutrons, different methods of pulse shape discrimination are tested; a 100 MHz Flash ADC system is compared with more conventional methods. Pulse shaping electronics are also investigated.

A Study of Compact Radio Sources

Steven Rosenberg
Sponsors: Marshall H. Cohen and Ann E. Wehrle

Using the radio astronomical technique of very long baseline interferometry (VLBI), I mapped four quasars during my SURF and measured their compactness using compactness criteria developed in my work. The quasars are named 0336-019, 0552 + 398, 1334-127, and 2345-167. The latter three sources had been mapped previously with incomplete data, and the first had never been mapped before. All except 2345-167 were compact, with ninety percent of their total flux density lying within a circle of diameter less than three milliarcseconds. The other source was a compact double, resolvable using baselines of over 5000 kilometers.

Infinite Games

Maneesh Sahani
Sponsor: Alexander S. Kechris

An infinite two-person game, G, is a subset of ω_ω. Two players alternate in choosing numbers and one wins if the resultant sequence is in G. If it is in the complement of G the other wins. A game is determined if either of the two players has a winning strategy. The contention that all games are determined is called the Axiom of Determinacy (AD). The paper reviews various types of games and the consequences of AD. In particular it shows that AD implies the Lebesgue measurability of all sets of **R** and so negates the full axiom of choice, but also implies countable AC. Other topics such as the consistency of various weaker forms of AD with AD are discussed.

The Galactic Warp in IRAS Sources

Craig Sosin
Sponsor: S. George Djorgovski

Although surveys of neutral hydrogen in the galactic disk have shown that the disk is not perfectly flat, but instead systematically warped in the outer regions, previously the warp could not be seen optically due to absorption by interstellar dust. Using the IRAS Point Source Catalog, with extragalactic sources filtered out, we have found that the distribution of infrared sources in the galactic disk shows a similar warp. Since most of the sources that we used are older giant stars, this result indicates that the warp is more than a short-term phenomenon.

Investigations on Spectral Properties of Certain Operators on $L^2[0,1]$

Balaji Srinivasan
Sponsor: W.A.J. Luxemburg

We studied the relationship between a compact operator and its spectrum and the compact action of hyponormal (and general) operators on their centralizers in the context of the invariant subspace problem. We also investigated the Bishop operator and attainable lattices of subspaces for a counterexample to the problem. All operators were in B(H), for H an infinite dimensional separable Hilbert space.

Transfinite Processes in Real Analysis

Glenn Tesler
Sponsor: Alexander S. Kechris

Transfinite induction is a concept from set theory which generalizes induction on the integers to transfinite sets. Applications of it in real analysis are examined, with particular emphasis on transfinite processes. Ranks associated with these processes characterize various notions of complexity of functions and sets. Functions and sets having arbitrary values of each rank are constructed. Examples are taken from topology, integration theory, differentiation theory, and ergodic theory.

Magnetic Monopole Detection with Benzene Ring Currents

Jeff Tseng
Sponsor: Barry C. Barish

The effect of a (GUT) Grand Unified Theory magnetic monopole on the pi-orbitals of a benzene ring was investigated. In addition to the normal velocity-dependent excitation caused by a monopole passing in the vicinity of the molecule, a velocity-independent excitation was found to be caused by the monopole passing directly through the ring. Methods to detect the presence of this very stable excited state are investigated.

Computing and Computer Science

Evaluating the On-Line Help Mechanism of the New World of Computing

Pennington Ahlstrand
Sponsor: Frederick B. Thompson

Most software available today comes with a thick, glossy user manual. Users need manuals to help them learn the complete capabilities of their software, as well as to fully explain and define terminology. At present, the New World of Computing, a commercial prototype natural language processing system, does not have a hard copy manual. Instead, it incorporates an on-line help mechanism. Interpreting the results of a semi-formal evaluation of that mechanism will answer the following question: Is the current on-line help sufficient for users of the New World system?

Macintosh/Powerace Digital Analyzer/Simulator

David G. Emerson
Sponsor: Geoffrey C. Fox and Rod M. Goodman

This program utilizes the Macintosh computer as a source of waveform generation and reception, allowing programmed data sequences consisting of eight signals to be written to, and read from, a Powerace breadboard. It will ultimately integrate external hardware with software circuit simulation. Immediate usage will be to aid in classroom digital circuit instruction and design (CS/EE 11). It also conforms to the user-friendly Macintosh interface guidelines.

Graphics Display of Concurrent Program Execution

David Knight
Sponsor: Paul C. Messina

To help determine whether a particular node on the iPSC Hypercube is suitably active, we proposed to set up a system whereby all message-passing events could be logged out to a file and then loaded into a SUN workstation. This program would represent these activities in a user-friendly environment. We started by studying a set of portable high-level macros coded at Argonne National Laboratory, which after much work were found to be inoperative. Thus I wrote a set of macros using lower-level system routines. This major setback will result in a very limited yet functional version of the display program.

QED Hypercube Connection Machine Calculation Comparison

Kevin Luster
Sponsor : Geoffrey C. Fox

The hypercube is a medium-grained MIMD parallel processor with a hypercube network topology developed at Caltech for use in solving physics problems that are inefficiently mapped onto sequential processors. Various programs exist that calculate QED parameters by mapping a four dimensional space-time lattice onto individual nodes of a hypercube. The current version simulates a cube of length equal to 16 nodes. The connection machine is a 16K node Single Instruction, Multiple Data (SIMD) parallel processor with a 2D grid network topology. The SURF involved comparing the suitability of the two machines for QED calculations.

Asteroids

Theodore Mlynar
Sponsor: Geoffrey C. Fox

The SURF I participated in consisted of the development and implementation of a space-based warfare simulation. This program effectively and efficiently utilizes the parallel architecture of the NCUBE10 and its corresponding parallel graphics board. It is patterned after a 3-D tunneling "Asteroids" theme that will be suitable for play by human and computer-simulated players. I was particularly involved in the graphical display necessary for a human user.

Development of Software for the Hypercube Simulator

Jonathan J. Schiff, University of California at Santa Cruz
Sponsor: Geoffrey C. Fox

My SURF project was to help in the development of software for the hypercube. I did not work directly with the hypercube, but rather with a software package that simulated it. I made corrections and embellishments of numerous programs written in C and FORTRAN and tested them under both the XENIX and VMS operating systems. My work has contributed to the improvement of a library of programs which demonstrate the ability of the hypercube to effectively handle a wide variety of algorithms and the methods used to implement them.

Project SEED

Science Education for Early Development

The Phototaxic Vehicle

Golda Bernstein
Sponsor: James M. Bower

The Phototaxic Vehicle is part of a series of hands-on science projects designed for elementary school students called Project SEED. The vehicle can exhibit four different behaviors in response to light. Students will do various experiments to analyze these behaviors and their relationship to the circuitry of the car. We hope the students will learn something not only about batteries, motors and photocells, but also about collecting data and working on their own initiative to solve simple problems in science.

Computer Simulation for Elementary School Science Project

Edward Lee
Sponsor: James M. Bower

Developed under Project SEED last year, "Batteries and Bulbs" (B&B) is a computer simulation program that lets elementary school children construct circuits on the Macintosh computer with various kinds of batteries and bulbs. Included in B&B this year is a new monitoring system that takes "snapshots" of the circuits as they are built by the elementary school children. These snapshots are chained into a "video" of circuits. With the aid of a new feature in the "Class Monitor" program, the teachers can then play back the videos and see the progress of their students.

Computation and Neural Systems

Use of Computer Simulations in Elementary School Science Education

Pamela Ling, Harvard University
Sponsor: James M. Bower

A comprehensive teaching package has been developed to facilitate the use of specialized computer software in elementary school hands-on science education. The package combines hands-on science activities, computer simulations, teaching methods, and curriculum extensions into a series of lesson plans appropriate for first or second grade. This teaching guide has also been converted into a piece of computer software that may be used with the computer simulations in a classroom.

Plants

Bruce Macartney-Filgate
Sponsor: James M. Bower

My SURF was with Project SEED, a pilot project in education through hands-on science. I worked on "Plants," a program which allows children to simulate growing seeds using their own weather patterns. We based our approach on teacher suggestions and observations of children using the program.

Naval Architect

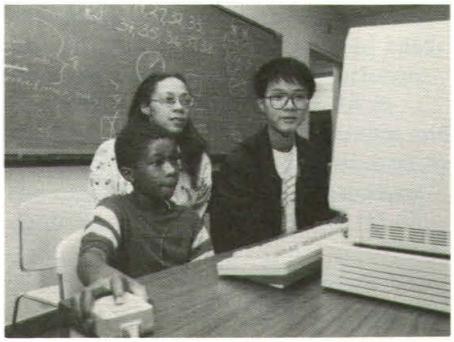
William Mitchell
Sponsor: James M. Bower

Naval Architect is conceived as a computer program for the Apple Macintosh, targeted at third- to fifth-grade students, which allows the design of a boat of quite arbitrary shape. This boat can then be tested in various aspects of performance, including drag coefficient, load capacity, and stability. The end of the summer finds the editor and load capacity portions of the problem largely completed.

A Boat Design Simulation for Secondary School Science Education

Peter M. Richardson
Sponsor: James M. Bower

Computer simulations allow students to explore areas of science that are too expensive, time consuming, or unwieldy for a typical classroom. A boat design simulation was constructed to enable young students to study the relationship between hull design and boat properties such as cargo capacity, stability, and speed. Expandability and ease of use were primary concerns in designing the program.



Wire Reduction Scheme for Neural Net Based Speech Recognizer

Ahmed Abd-Allah
Sponsor: John J. Hopfield

Most analog multiplexing is done through time division; that is, sampling the individual signals as rapidly as possible. However, since this method is always limited by the Nyquist criterion, we decided to explore a multiplexing scheme that depends solely on range division. The result was that we designed and successfully tested a discrete circuit which multiplexed several signals through a series of quantizations and scaled additions. Our circuit had no Nyquist limitations, but was hindered by the speed of our hardware instead. With some modifications, this circuit can be condensed onto an integrated circuit level.

Computing Optical Flow in the Primate Visual System Using Biological Neural Networks

Andrew Hsu
Sponsor: Christof Koch

Computing motion based on time-varying image intensity is a difficult problem for both artificial and biological vision systems. One method for estimating visual motion employs a well known gradient-based computer algorithm. This algorithm can be mapped onto a neural network where individual neurons code for motion in one preferred direction. The network compares to the magnocellular pathway of the primate visual system, from the primary visual cortex to the middle temporal area. By using this network to compute motion, a number of psychophysical experiments and illusions as well as electrophysiological findings can be explained.

Simulated Neural Network Models of the Vestibulo-Ocular Reflex

Steven Ludtke
Sponsor: James M. Bower

The vestibulo-ocular reflex is responsible for producing the higher frequency (2-10hz) components of compensatory eye movements used to provide a stable image to the retina during head motion. The VOR receives velocity signals from the inner ear and uses these to create positional signals for the eyes. In other words, it acts as an integrator. The first part of this project was to take proposed neural network models of the VOR and simulate them using a neural network simulator recently developed here at Caltech to see if they would react as their designers claimed. The second part of the project was, working with Dr. M. Paulin, to create an improved network with more realistic responses which might eventually be linked with models of the cerebellar cortex. The first stage of the project is complete; previously proposed models have been modeled and their results are as predicted. The second stage of the project is still in progress.

Using Neural Modeling for Realistic Animation of Animal Locomotion

Mark Montague
Sponsor: Alan H. Barr

This project's goal is to apply the extensive work done by neurobiologists in understanding the spinal basis of locomotion toward developing realistic animations of animals. The main thrust of the project in the summer of 1988 was researching the neurobiological aspects of locomotion, particularly in cats. So far, I have determined that it should be possible to write a reasonably simple simulation of the cat's spinal stepping and gait controls, allowing a simple animation of the animal automatically switching between a walk, a trot, and a run, but a fairly complex dynamic model of the cat's body needs to be constructed first. I hope to finish this by the end of the summer.

Modeling Neural Network Using Volume Holography

James Hsi-Jen Yeh
Sponsor: Amnon Yariv

A new holographic configuration for realizing neural network models was constructed and tested. The configuration utilizes a separate volume hologram to model the interconnections of each neuron. For each synaptic interconnection to a neuron, a diffraction grating with diffraction efficiency proportional to the synaptic strength is stored in the hologram modeling that neuron. Thus, for a given state of the network, the input to a particular neuron appears as the total light diffracted from the corresponding hologram. Calculations show that with $LiNbO_3$ (lithium niobate) as the holographic medium, 10^8 interconnections (corresponding to 10^4 neurons) can be stored in a 10 cm $\times$ 10 cm $\times$ 0.1 cm plate; yet this is only one percent of the estimated theoretical capacity. A network model with six neurons is being tested to verify the basic process.

Correction of Distortion and Correlation of Features in Infrared Images of Jupiter

Ian Avruch, Brandeis University
Sponsor: Glenn S. Orton

Images taken of Jupiter in the infrared (wavelengths of 5 to 18 microns) at the infrared telescope facility in Hawaii reveal a level of detail previously unseen. Careful analysis requires first correcting for distortion of the images due to tracking errors at the telescope and rotation of Jupiter. Correlation or anticorrelation between wavelengths gives insight into the properties of the Jovian atmosphere. At some wavelengths, structures are revealed within the main latitudinal bands, and at 7.8 microns, the north polar hot spot can be seen to traverse the planet fixed with respect to System III longitude.

StarRocks

Robert Coker and Celina Mikolajczak
Sponsor: Eleanor F. Helin

Through participation in the Planet Crossing Asteroid Survey (PCAS), we were part of a team searching near opposition ecliptic films taken on the Palomar 18-inch Schmidt telescope for asteroids which cross the orbit of Mars or Earth and asteroids with highly inclined orbits. As a result, our group discovered 43 objects. This includes at least one Amor [1988PA], one Hungaria and three Phocaeas. In addition, we had our own search program for high inclination objects. We were directly credited with the discovery of at least seven objects. Our own search program covered over 1500 square degrees of sky complete to eighteenth magnitude.

Investigation of Light Curve Behavior of Asteroids Through the Observation and Reduction of Photometric Data

Luisa Contreiras, Massachusetts Institute of Technology
Sponsor: Alan W. Harris

The purpose of this SURF was to investigate the photometric properties of asteroids. Photometry is the research of light and the factors that affect the varying brightness of an asteroid, namely the asteroid's rotation and the varying solar phase angle. Photometry is a two-part process, observation and data reduction. The reduction of instrumental magnitudes obtained from the photometer will produce absolute magnitudes, which when plotted against time will give a light curve illustrating the varying brightness of the asteroid during one rotation period. One can further plot magnitudes as a function of the solar phase angle, a phase curve. In this case, the asteroid 64 Angelina did not appear to display conventional light curve behavior, indicating that there might possibly be previously undetected complexities in the photometric behavior of asteroids. Formal reduction of the data obtained earlier this year indicated that the asteroid 64 Angelina demonstrated unconventional behavior at extremely low phase angles, making it necessary to reassess asteroid behavior and develop new theories that explain the particular behavior of the brightness of asteroids that will account for the behavior displayed by 64 Angelina.

Crystal Growth

Neil Crawford, University of California at Berkeley
Sponsor: Paul J. Shlichta

1. To study the nucleation and growth, under various conditions, of protein crystals, a standardized procedure for growing lysozyme crystals reproducible was needed. The optimal pH, temperature, and concentration (protein and precipitating agent) for growth of large, single crystals were found, but a large scatter in nucleation times, due to the onset of spurious nucleation, was observed.
2. To grow large, single-protein crystals, nucleation of new crystals must be minimized. A study of nucleation-inhibiting surfaces for crystal growth containers indicates that nucleation of lysozyme crystals is inhibited most by fluorocarbon oils, less by fluorochlorosilane-treated glass, less by PROSIL-treated glass, and least by untreated glass. Although they give the best results, fluorocarbon oils are the most difficult to use because they are liquids.

Synthesis and Optical Characterization of Metalloporphyrins

Clifton Kiser
Sponsors: Minoo N. Dastoor and Ruth Margalit

Based on semiconductor technology, the current generation of computers is approaching the stage where their power will be limited by the fundamental physical constraints imposed by the fabrication of these devices. Molecular electronics, based on the rapid intermolecular electron transfer in photoreactive metalloporphyrins, provide possible solutions to the problems of achieving high-density packing, minimizing the size of the basic switching unit, and reducing the energy requirements for the switching unit. The first stage of a multi-year project headed by Ruth Margalit of JPL, this paper discusses the synthesis and optical characterization of several photoreactive metalloporphyrins.

Studies of Low Temperature Extraterrestrial Ices

K. Justin Lawyer
Sponsor: Vince G.Q. Anicich

The absorbance spectra of various substances (mostly primitive organics) were taken in the MIDIR range (5000-500 wavenumbers) while they were in the gas phase. Those spectra were then compared to spectra taken of low temperature ices of the same species. The ice spectra was noted to lose the vibrational levels of the gas phase and only retained the q branch structures and overtones, as was expected. Also, acetylene and ethylene were deposited in CO and Ar matrices. In general, despite the limited matrix database, any particular absorption peak was noted to shift to lower energy wavelengths (lower wavenumbers) as the substance went from gas phase to COO matrix to Ar matrix to ice phase.

Pressure-Composition Isotherms of the Manganese Nitride-Nitrogen System

Alan Lund
Sponsor: Jack A. Jones

The equilibrium temperatures and pressures have been measured for a system of finely powdered manganese nitride and nitrogen gas at 650, 700, 800, and 850 degrees Celsius for various nitrogen loadings. Pressures ranged from less than 0.2 atm at 650 degrees to 63 atm at 850 degrees. Due to the slow kinetics of the reaction and the high specific power, this system is not feasible for use as a compressor for sorption refrigeration.

Analysis of Text Using a Neural Network: A Hypercube Implementation

David Newhall
Sponsor: Joan C. Horvath

Artificial neural networks have been shown to be useful for solving a variety of problems traditionally thought difficult using the classical von Neumann computer architecture. This paper presents an implementation of a simulation of a "backpropagation" neural network using the 32-node Caltech/JPL Mark III Hypercube concurrent processor. The network is designed for text pattern recognition, and is sufficiently general that the actual problem to be solved is defined at run time. The problem used for efficiency and generalization studies was that of recognition of the names of the ten digits written in text. In order to test how well the patterns had been learned the network was presented with a set of patterns it had not yet encountered, such as the names of the digits with various spelling errors. After a sufficient number of training examples, the network was consistently able to categorize these novel patterns with at least 80% accuracy. For this problem, the efficiency of the algorithm's use of the parallel resources was on average 91% for 4 nodes, dropping to under 70% for 16 nodes. For larger problems, the 16-node efficiency was as high as 89%. These statistics are discussed in greater detail, as well as factors influencing the network's performance in solving novel problems.

Path Integrals, Simulated Annealing, and Robotics

Christopher Oei
Sponsor: John J. Beahan

Different algorithms were created and tested for finding a path of a robot arm through a field of obstacles. These algorithms work by finding the path which minimizes a quantity which is analogous to the action in mechanics. The minimizing, or optimizing, algorithms are based on the annealing processes in statistical physics. This approach can take full advantage of the power of parallel processing as well as further heuristics.

Measurement of RF/DC Plasma Potential by an Emissive Probe

Daniel Pang
Sponsor: Philip L. Leung

This project involves the study and construction of an emissive probe and its use in the measurement of radio frequency (RF)/DC plasma potential. For DC potential, an emissive probe is used, as opposed to a cold probe, because it is insensitive to primary electrons. A cold probe samples energetic electrons at its floating potential and gives a false representation of plasma potential. The emissive probe's floating potential approaches plasma potential asymptotically as emission is increased, and thus yields a truer representation. For RF potential measurements, the probe can follow rapid fluctuations in plasma potential of several volts magnitude, and is thus a good measuring instrument in plasma. By decoupling the probe's heating circuit from the emissive probe during the few milliseconds for the potential measurement, the probe can measure fast potential variations on the order of tens of nanoseconds. By sampling and processing the potential signal of the emissive probe in real time, the self-consistent RF electric field in the plasma can be measured directly. One of the frequencies of interest will be at 20 KHz as this simulates the RF frequency on a space station. Other frequencies inherent to different plasma modes will also be investigated. At present, DC measurements have been performed and RF measurements are in progress.

Steps Toward Plasmid Vector Stabilization-Transduction and Plasmid Construction

Alice J. Paquette, Massachusetts Institute of Technology
Sponsor: Giuseppe Bertani

In order for a growing bacterial culture to retain a plasmid vector, it must be kept under continuous antibiotic selection. This requirement could be eliminated, however, by associating the vector sequences to the chromosome in high copy number. The development of such a system involves many steps, including plasmid construction and genetic manipulation. Functional *att* sequences of bacteriophage P2 were inserted into the plasmid vector PBR322 to allow for ampicillin selection (instead of the tetracycline selection required by a similar, pre-existing construct), and attempts were made to revert a ts*polA* mutant to *polA*$^+$ by infecting the mutant strain with the transducing phage P1 grown on a *polA*$^+$ host and selecting for recombinants.

Characterization of Iron Mesoporphyrin IX Doped Nafion^R Thin Films

Ronald T. Park
Sponsor: Ruth Margalit

The possibilities of using bio-organic materials that possess novel electrical properties for electronic device applications were studied. Specifically, a characterization of thin films of iron mesoporphyrin IX (iron heme extracted from myoglobin) doped nafion was conducted. Physical characterization included studies of the quality, mechanical strength, and stability in oxygen environments of the films. The films were of good quality and physically stable; however, they lacked mechanical strength. Electrical characterization involved determining the current voltage (I-V) relationships. The thin films possess asymmetric I-V characteristics. Depending upon the direction of electrical bias across the films, they acted as insulators or displayed a hysteresis. The asymmetry of the I-V behavior is suspected to be a result of self*organization of the porphyrin and nafion molecules in the film. The electrical bistability is attributed to oxygen binding.

Isolation of One or More Deletions Involving Essential Genes of a Phage Vector and Thus Causing the Vector to Exhibit a Nearly Uniquely Restricted Host-Range

Melissa Rapp, University of California at Irvine
Sponsor: Giuseppe Bertani

"Vectors" such as bacteriophage are the tools used in genetic engineering for the transfer of DNA. While phages perform genetic transfer efficiently, they are limited in the amount of DNA they can carry. The phage's foreign DNA capacity may be increased

by deleting non-essential genes. This project attempts to further increase this capacity in a phage called P2 by also deleting essential genes. The deleted phage would be inviable in its ordinary host, but active in special strains which have been genetically altered so that they supply the lacking essential genes. Thus, this increased capacity makes it a more versatile vector as well as one that is safer due to its restricted host-range.

Signposts for a Mature Technology: Examples from Image Tubes and CCDs

Brad Roberts and John Villani, University of Pennsylvania
Sponsor: William M. Whitney

The life cycle of a technology contains several stages, each demanding different management goals and foci. All technologies eventually enter a mature stage, in which the technology has reached its performance limits. The challenge for managers is to determine when a technology is reaching this mature stage, so new research strategies can be formulated. Research shows that during the twenty years of JPL involvement in the technology, image tubes reached maturity. The study analyzes the life cycle of the image tube for space applications and proposes several signposts that appear to have signalled the coming of this maturity. The research then examines the development of CCDs with respect to these signposts.

Simulating Arms

Raymond Sidney
Sponsor: Mark H. Milman

I spent most of my summer programming routines to simulate a robot arm. These routines included a general-purpose ODE solver and a general-purpose program to make well-behaved curves to fit supplied endpoint conditions, as well as numerous enclosing packages to fit forward-dynamics and inverse-dynamics routines into the integrating routines.

Numerical Simulation of Solar Wind Density Fluctuations and Their Effects on VLF Radio Interferometry

Robert S. Williamson III
Sponsor: Dayton L. Jones

An orbiting array of small satellites has been proposed to investigate radio frequencies from 2 to 20 MHz, a range unobservable from the ground due to ionospheric absorption and aberrations. Such a mission seems feasible, inexpensive, and of low complexity, but further investigation is still necessary. One major area of concern is the solar wind, a supersonic stream of free electrons and protons flowing radially outward from the sun's corona. This wind is full of turbulence-induced random density variations which cause a fluctuating phase shift in any electromagnetic signal passing through. These phase fluctuations can sometimes make radio source imaging impossible. A numerical simulation has been developed which accurately characterizes solar wind density fluctuations. Results have allowed more accurate conclusions to be drawn about observing constraints and have shown that imaging at very low radio frequencies is feasible.

Photometry of Uranus's Satellites

Felicity Wong
Sponsor: Bonnie Buratti

A combination of Voyager and groundbased photometric data of Uranus' satellites was reduced and normalized to give phase curves for Oberon, Titania, Ariel and Umbriel. Phase integrals and spectral geometric albedos were derived. The satellites are spectrally flat and have low albedos. By comparing these results with a scattering model, constraints will be obtained for the single scattering albedos, single particle phase functions, porosities and macroscopic roughness of these objects.

Asteroid Photometry on 1685 Toro

Julie Yee
Sponsor: Alan W. Harris

Once every four years, the asteroid Toro is within observing distance (less than 0.40 a.u.) from Earth. This summer of 1988, the asteroid was to come within a minimum distance of approximately 0.18 a.u. After taking photometric measurements at Table Mountain Observatory of Toro and nearby comparison stars, we were able to determine, by photometric data reduction techniques, the varying brightness of the asteroid with change in time. A lightcurve resulted, and the rotational period for the asteroid was calculated. These results compared with the results in earlier publications on Toro will be discussed.

MicroMITES

Microwave Microwatt Interferometry and Telemetry Experiment Satellite

Development of a Transmitter System for a Cheap X-Band, Ka-Band Experimental Satellite

Dimitrios Antsos
Sponsors: Robert C. Clauss, Edward C. Posner, Joel G. Smith

A deep space vehicle needs to be able to do two things in order for it to be of any use: 1) transmit data to the earth, and 2) be trackable from the earth so that we can get data when we want it, from where we want it. New Ka-band frequencies (at 32 GHz) permit higher data return rates on the down-link. That is why they are desirable. (The more data we get during each encounter, the better). An experimental satellite is being developed by a group of Caltech SURF students to compare the effects of weather on a Ka-band downlink to those on an X-band downlink and to do an interferometry tracking experiment. My part of this SURF has been to develop the 8.45 GHz X-Band transmitter.

MicroMITE Satellite Receiver

John S. Chen
Sponsors: Robert C. Clauss, Edward C. Posner, Joel G. Smith

The μMITE satellite is expected to simulate a deep space probe by emitting tones at X-band and the experimental Ka-band. A radio receiver will control the transmission of these tones. Among the essential considerations of the design are the signal power at the receiver and its variation; the amount of information to be conveyed; efficiency in terms of the power consumed; and the "complexity" of a particular design.

MicroMITE Satellite Power Supply Design

George Fang
Sponsors: Robert C. Clauss, Edward C. Posner, Joel G. Smith

The μMITE satellite's power consuming payload, which includes an X band transmitter, a Ka band transmitter, and an X band command receiver, will require a maximum power of approximately four to five watts. The power for the satellite is to be supplied by only solar cells; no battery will be used. Therefore, it will operate only while it's in sunlight. The solar cells will be placed on all available planar surfaces of the satellite. Then, all of the cells on the same surface will be connected as an array with the maximum power point at 28 volts. A DC-to-DC voltage step-down converter is used on each array to produce the 15 volts bus voltage. All of the arrays will be linked in parallel to increase the power output capacity. During the summer a voltage step-down converter has been designed and a breadboard unit built. The efficiency is about 80%; however this could be improved a little with the use of better components. In the '88-'89 school year, this design's feasibility will be examined more closely, and by the beginning of next summer, the construction of the actual circuit will begin.

Off-Campus

MicroMITE Antenna System Design

Meera Srinivasan
Sponsors: Robert C. Clauss, Edward C. Posner, Joel G. Smith

The microMITE satellite is a tumbling spacecraft with no attitude control; hence the antennas must provide 360° coverage. As few antennas as possible should be used in order to minimize complicated interference patterns. Two antennas placed on opposing sides of the satellite, each with 180° coverage, would be ideal. Such a design for a hemispherical coverage waveguide antenna has been found, and a test model built. The results of the antenna tests in terms of radiation patterns are presented here.

Frequency Multiplication Scheme of MicroMITES

Terence Dat-Hung Yeh
Sponsors: Robert C. Clauss, Edward C. Posner, Joel G. Smith

The object of μMITES is to design the communication system of an earth-orbiting satellite simulating a deep space vehicle by transmitting a very weak signal at the conventional X band and the lesser known region at Ka band. However, the X band signal at 8.45 Ghz and the Ka band signal at 32.11 Ghz have to be coherent, related in frequency by a ratio of 3.8. In this report, various frequency multiplication schemes are considered and evaluated. The best scheme is picked and investigated in full detail. Possible implementation is intended. Thus, components commercially available are studied fully. A few components not available commercially are designed to fit our scheme. Lastly, some hardware testing and integration of the overall systems are possible if time allows.

Study of Superconducting Transducers

Eric Candell
Sponsor: William O. Hamilton

We have investigated A.C. losses in Niobium at 1 KHz. A transducer was designed to facilitate studying the effects of different types of superconducting ground planes on electrical Q. This device allowed changing of ground planes without disturbing any other factor that could effect the electrical Q. Quality factors of thin foil Niobium, bulk Niobium, and pancake coils wound of 5 mil Niobium wire were measured.

Passive Protocol Monitor

Ruchira Datta
Sponsors: Rod W. Black and Nick T. Silva

This project consisted of designing firmware in C for a passive protocol monitor. The passive protocol monitor is a device which can monitor digital communications protocol lines without interfering with the transmission of information. A digital communications protocol line consists of a signalling channel and two information channels. Information transmitted on these channels may be encoded using any of several protocols. The firmware designed in this project decodes the data transmitted on the line into readable form, given which protocol is being used. Thus, for example, a particular sequence of bits may be decoded to mean "Dialed Ascii 5," indicating that the digital endpoint (e.g., terminal) has performed the equivalent function to dialing a 5 on its telephone.

Probabilistic Determination of CMOS SRAM Reliability

Kevin Underhill
Sponsor: Yeong Song

The dc CMOS memory cell current model was developed from transistor level analysis. Radiation effects were introduced as normally distributed changes in oxide and interface trapped charge which, in turn affect the individual transistor parameters. Programs were then written to develop the current distribution of individual cells and then to obtain the probabilistic current output solutions for the 1K SRAM.

A Study of the Errors in Estimating Phytoplankton Abundances Associated with Different Sampling Intervals

Miriam Yee
Sponsor: George Jackson

Modifying a method for objective analysis based on the Gauss- Markov Theorem and put forth by Bretherton et al. (1976), a technique for determining the appropriate sampling intervals of phytoplankton was developed. This technique was used on actual data of phytoplankton counted by Allen at the Scripps Institution of Oceanography pier. A time series analysis was done on the Allen data and the results were then used to calculate the errors in estimating phytoplankton abundances associated with different time intervals between samples.

Isolation of M.A.S. in *Microciona prolifera*

Kyuson Yun
Sponsor: Max Berger

This project focused on understanding the mechanism behind cell-to-cell recognition inmarine sponge *Microciona prolifera*. In particular, attempts were made to isolate protein domains of the *Microciona prolifera* aggregation factor (M.A.S.) and to clone the genes coding for this proteoglycan-like aggregation factor.

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