Environmental Bioremediation and Biodegradation

A MEETING SUMMARY

The Keystone Symposium *Environmental Bioremediation and Biodegradation*, organized by Drs. James J. Valdes, Ananda M. Chakrabarty and Michael Bagdasarian, was held March 6 – 12, 1993 at Granlibakken, Lake Tahoe, California. The abstracts of the meeting were published in the JOURNAL OF CELLULAR BIOCHEMISTRY, Supplement 17C, 1993 (ISSN 0730-2312).

The purpose of the meeting was to bring together the leading scientists and engineers in this diverse area to further dialogue between those conducting basic mechanistic research and those designing fieldable systems, within the context of policy guidelines. The meeting was attended by 110 participants representing industry, academia, and government institutions, from 11 countries on 5 continents. To accomplish the goals of the symposium, the talks were arranged broadly into sessions covering basic molecular genetics, microbial physiology and biochemistry, applications and engineering systems, fate and effects and monitoring, and policy guidelines. In addition, there were poster sessions throughout the week.

One basic tenet of bioremediation is the occurrence of gene transfer between organisms which confers new properties on the recipient. Dr. Robert Miller described studies using virus vectors to transform bacteria and conditions resulting in the lysogenic response. The natural abundance of bacteria and phage particles in aquatic environments make subsequent infection of the bacterial community possible. Molecular genetic approaches also challenged the notion that dichloromethane dehalogenases were relatively recent adaptations to pollutants. Dr. Tom Leisinger's work suggests that it evolved in cyanobacteria and proteobacteria as a defense against oxygen toxicity and is, in fact, very ancient.

Other, more practical, observations include Dr. Michael Bagdasarian's work which showed that genetic regulatory sequences in soil bacteria act differently under starvation conditions than in culture. It therefore follows that one should select for promoters which function under these conditions, i.e., activate systems in soil under starvation conditions. Similarly, Dr. John Reeve looked at genes which cope with growth vs. non-growth (i.e., starvation) conditions. Using methanogenic organisms, he described studies aimed at activating methyl reductase systems under starvation conditions to achieve substrate degradation without growth of biomass. Another example of a practical application of a mechanistic observation was Dr. Gil Geesey's work defining the surface characteristics which stimulate exopolysaccharide production by bacteria. These biofilms often block bioreactors and injection wells, but can also be used to block the spread of plume of pollutants in ground water.

Lignin degradation was an important topic and Dr. Michael Gold's discussion of a proposed mechanism by which white rot fungi degrade lignin and many other aromatic pollutants produced the most incendiary debate at the meeting. Briefly, he proposed that peroxidases depolymerize lignin and the monomers are taken up by the fungi and oxidized to quinone, which is then degraded further by either reduction or methylation. Drs. C. A. Reddy, Steven Aust, and Irwin Gunsalus further elaborated on lignin degradative pathways.

Methanogens are a very diverse group of extreme anaerobes which were also discussed at length. Drs. Tom Leisinger, Mary Lindstrom and John Reeve led much of this discussion which centered on the genetic messages for methyl reductase, and manipulation of substrate specificity by altering nutrient conditions.

A great deal of time was spent discussing biodegradation of haloaromatic, alkylated aromatic, and methoxyaromatic compounds. Dr. Joseph Suflita focused on a group of gasoline additives while Dr. Ronald Unterman discussed the treatment of TCE contaminated water. The latter used a genetic approach to separate the desired catalytic activity from metabolic regulation by using selective promoters, and also described a sequential aerobic/anaerobic approach to solid phase treatment of waste.

Sensitive monitoring and detection technologies are crucial to both locating toxic wastes and monitoring the condition of microbial systems. Biosensors and recently been developed which detect picogram quantities of chemicals and toxins, and work with a number of these technologies was discussed by Dr. James Valdes. Dr. Ronald Atlas described a modified PCR method to probe for genetic markers in soil as a way to monitor the presence of viable bacteria, and an enzyme amplified oligonucleotide probe technique.

This meeting was unique in its emphasis on applications and engineering, and closer cooperation between microbiologists and process engineers will be critical to the future. This need was evident by the rather spirited debates between these disparate disciplines which emphasized the lack of agreement on many issues from nomenclature to mathematical modeling. Dr. Rodolfo Quintero described a massive water remediation project in Mexico, Dr. Eugene Rosenberg described a successful remediation of an oil contaminated beach in Israel, Dr. Murray Moo-Young discussed airlift bioreactor systems in Canada, and Dr. Robert Hickey detailed plans for sediment remediation at the Savannah River site. The gulf between the biologists and engineers was most apparent in the heated discussion of Monad Kinetics which followed Dr. Leslie Grady's talk on mathematical modeling and system design.

Finally, discussions of policy issues and funding were raised in the final session. Mr. Walter Mikucki from the Army Corps of Engineers presented an overview of the Army's environmental problems and programs, and Dr. Hap Pritchard presented regulatory issues of concern to the Environmental Protection Agency. Many other papers and posters were presented and all had one thing in common other than outstanding quality — a recognition that neither the biologist nor the systems engineer can afford to live in a vacuum if bioremediation systems are ever to be successful on a large scale.

The Keystone Symposia organization will recommend that a second meeting be held in 1995 with Dr. James Valdes as Organizer/Chairman. A relatively greater emphasis will be given to issues of "concurrent engineering" approaches to science and engineering, and workshops to bring the many relevant disciplines together.

PROGRAM REVISED 2/25/93

a Keystone Symposium

ENVIRONMENTAL BIOREMEDIATION AND BIODEGRADATION

Organizers: James J. Valdes, Ananda Chakrabarty and Michael Bagdasarian

March 6-12, 1993, Lake Tahoe, California

Sat 3/6

2-7pm	Registration	Lobby/Bay Room
6:30-7:30pm	Social Hour	Granhall
7:30-8:30pm	Dinner Buffet	Granhall
8:30-9pm	Orientation	Mountain

Sun 3/7

7-8am	Breakfast	Granhall
8am-12pm	MOLECULAR GENETICS AND PHYSIOLOGY OF MICROORGANISMS *(Session Sponsored by: U.S. Army Research Office)*	Mountain/Lake

Irwin Gunsalus * Univ Illinois-Urbana
Michael Bagdasarian Michigan Biotechnology Inst
"Gene Manipulation in Soil Bacteria"
Ronald Olsen Univ Michigan-Ann Arbor
"Degradation of Alkyl-Substituted Benzenes by Bacteria Functional Under Oxygen-Limited Conditions"
Coffee Break
Gill Geesey Montana State Univ
"Reporter Gene Activity as a Means of Evaluating Exopolysaccharides Production by Bacteria in Reactor Systems"
Kensuke Furukawa Kyushu Univ-Japan
"Molecular Genetics and Ecology of PCB-Degrading Bacteria"
Ronald Crawford Univ Idaho-Moscow
"Designing Biodegradability into Industrial Chemicals: Using our Knowledge of Microbioal Biochemistry"

12pm-4pm	Poster Set Up	Bay Room
4-6pm	Posters: MOLECULAR GENETICS AND PHYSIOLOGY OF MICROORGANISMS; LIGNIN AND CELLULOSE DEGRADATION	Bay Room
5-6pm	Social Hour	Bay Room
6:30-7:30pm	Dinner	Granhall
7:30-11pm	LIGNIN AND CELLULOSE DEGRADATION	Mountain/Lake

Michael Gold * Oregon Grad Inst
"Degradation of Chlorinated Phenols and Chlorinated Dibenzo-P-Dioxins by Phanerochaete Chrysosporium"
Steven Aust Utah State Univ
"Biodegradation of Chemicals by White Rot Fungi"
Coffee Break
C. Adinarayana Reddy Michigan State Univ
"Lignin-Degrading Enzyme System of Phanerochaete Chrysosporium: Molecular Biology and Role in Organopollutant Degradation"

Mon 3/8

7-8am	Breakfast	Granhall
8am-12pm	ANAEROBIC DEGRADATION *(Session Sponsored by: U.S. Army Research Office)*	Mountain/Lake

James Tiedje * Michigan State Univ
"Anaerobic Metabolism of Chlorobenzoates, Phenols, Biphenyls and PCE by Novel Anaerobes"
John Loper Univ Cincinnati
"Bacterial Isolates, Recombinant Yeasts, and Microbial Systems for Degradation of Hazardous Compounds"
P.H. Pritchard Environmental Protect Agency
"Measures of Bioremediation Effectiveness in the Field"
Coffee Break
Joseph Suflita Univ Oklahoma-Norman
"Anaerobic Biodegradation of Aromatic Chemicals of Environmental Concern"
John Reeve Ohio State Univ
"Regulated Gene Expression During Methanogenesis"

12pm-4pm	Poster Set Up	Bay Room
4-6pm	Posters: ANAEROBIC DEGRADATION; AEROBIC DEGRADATION	Bay Room
5-6pm	Social Hour	Bay Room
6:30-7:30pm	Dinner	Granhall
7:30-10:30pm	AEROBIC DEGRADATION	Mountain/Lake

Thomas Leisinger * Fed Technical Univ-Zurich
"Chlorinated Methanes as Carbon Sources for Aerobic and Anaerobic Bacteria"
Burton Pogell Univ Maryland-Baltimore
"Streptomyces as Homologous and Recombinant Vehicles for Bioremediation of Pesticides, Nerve Agents, and Other Xenobiotics"
Coffee Break
Mary Lidstrom California Inst of Technology
"Oxidation of Small Halogenated Solvents by Methanotrophs"

Tues 3/9

7-8am	Breakfast	Granhall
8am-12pm	DETECTION AND MONITORING	Mountain/Lake

James J. Valdes * US Army
"Biosensors for Monitoring Chemical Pollutants in the Environment"
Gary Sayler Univ Tennessee-Knoxville
"Molecular Strategies in Biodegradation Process Monitoring and Optimization"
Coffee Break
Ronald Atlas Univ Louisville
"Molecular Methods for Detecting and Monitoring Microorganisms"
Betty Olson Univ California-Irvine
"Gene Occurrence and Expression in the Environment"
Anne Summers Univ Georgia-Athens
"A Biosensor for Mercuric Ion and Metallic Mercury Vapor"

12pm-4pm	Poster Set Up	Bay Room
4-6pm	Posters: DETECTION AND MONITORING; APPLICATIONS I	Bay Room
5-6pm	Social Hour	Bay Room
6:30-7:30pm	Dinner	Granhall
7:30-11pm	APPLICATIONS I	Mountain/Lake

Eugene Rosenberg * Tel Aviv Univ
Ronald Unterman Envirogen
"Biological Treatment of Chlorinated Organics-Laboratory and Field Studies"
Daniel Abramowicz General Electric-NY
"PCB Biodegradation in the Laboratory and in the Environment"
Coffee Break
Bernard Witholt ETH
"Biodegradation of Aliphatic and Aromatic Compounds en Route to Useful Syntheses"
Joseph DeFrank US Army
"Biochemical Demilitarization of Chemical Warfare Agents"

SPEAKERS

DANIEL A. ABRAMOWICZ
CORP RSCH/DEVELOPMENT CTR
GENERAL ELECTRIC COMPANY
PO BOX 8
SCHENECTADY NY
123010008
518-387-7072

RONALD M. ATLAS
BIOLOGY
UNIV OF LOUISVILLE
139 LIFE SCI BLDG
LOUISVILLE KY
40292
502-588-6771

STEVEN D. AUST
BIOTECH CTR
UTAH STATE UNIV
M 105-C
LOGAN UT
843224700
801-750-2730

MICHAEL BAGDASARIAN
MICROBIOLOGY
MICHIGAN STATE UNIVERSITY
ROOM S-110 PLANT BIOL BLDG
EAST LANSING MI
48824
517-353-8619

AL W. BOURQUIN
CAMP DRESSER & MCKEE INC
1331 17TH STREET STE 1200
DENVER CO
80202
303-298-1311

ERICH BRETTHAUER
OFFICE RSCH & DEVEL
ENVIRONMENTAL PROTECT
ENCY
M STREET, SW RD-672
WASHINGTON DC
20460
202-260-7676

CARL E. CERNIGLIA
NATL CTR TOXICOLOGICAL RSCH
DEPT HLTH & HUMAN SERVICES
JEFFERSON AR
72079
501-543-7341

ANANDA M. CHAKRABARTY
MICROBIOLOGY/COLL OF MED
UNIV OF ILLINOIS
901 S WOLCOTT AVENUE/MC 790
CHICAGO IL
60612
312-996-4586

RITA R. COLWELL
MICROBIOL
UNIV OF MARYLAND
COLLEGE PARK MD
20742
301-405-5189

RONALD L. CRAWFORD
MOLEC/AGRIC GENE ENGR
UNIV OF IDAHO
FOOD RESEARCH CTR RM 202
MOSCOW ID
83843
208-885-6580

JOSEPH J. DEFRANK
R D&E CENTER
US ARMY EDGEWOOD
BIOTECH TEAM SCBRD-RTS
ABERDEEN PROVING GRD MD
210105423
410-671-3972

KENSUKE FURUKAWA
AGRICULTURAL CHEMISTRY
KYUSHU UNIVERSITY
FUKUOKA
812 JAPAN
092-641-1101

DAVID J. GALAS
ENERGY
OFFICE OF HEALTH
ENVIRON RSCH
ER70
WASHINGTON DC
20585
301-903-3251

GILL GEESEY
ENGINEERING RSCH CENTER
MONTANA STATE UNIVERSITY
409 COBLEIGH HALL
BOZEMAN MT
597170398
406-994-4770

MICHAEL H. GOLD
CHEMICAL & BIOLOGICAL SCI
OREGON GRAD INST SCI/
TECHNOL
19600 NW VON NEUMANN DR
BEAVERTON OR
970061999
503-690-1076

C.P. LESLIE GRADY
ENVTL SYSTEMS ENGR
CLEMSON UNIVERSITY
RICH ENVIRONMENTAL RSCH
LAB
CLEMSON SC
296340919
803-656-5570

IRWIN C. GUNSALUS
BIOCHEMISTRY
UNIV OF ILLINOIS
1209 W CALIFORNIA ST/420 RAL
URBANA IL
61801
217-333-2010

ROBERT HICKEY
MICHIGAN
BIOTECHNOLOGY INST
3900 COLLINS ROAD
LANSING MI
48909
517-336-4630

THOMAS LEISINGER
MICROBIOL
FEDERAL TECHNICAL UNIV
ETH-ZENTRUM
ZURICH
8092 SWITZERLAND
01-256-3324

MARY E. LIDSTROM
138-78 KECK LABS
CALIFORNIA INST OF
TECHNOLOGY
PASADENA CA
91125
818-356-2132

JOHN C. LOPER
MOLECULAR GENETICS
UNIV OF CINCINNATI
3110 MEDICAL SCIENCES BLDG
CINCINNATI OH
452670524
513-558-0086

WALTER J. MIKUCKI
ENVRNMNTL SUSTNMNT LAB
US ARMY CONSTR ENG RSCH LAB
BOX 9005
CHAMPAIGN IL
618269005
217-373-3496

ROBERT V. MILLER
MICROBIOL/MOLEC GENETICS
OKLAHOMA STATE UNIVERSITY
307 LIFE SCIENCE EAST
STILLWATER OK
740780289
405-744-7180

MURRAY MOO-YOUNG
CHEM ENGR
UNIV OF WATERLOO
BIOCHEM ENGR GROUP
WATERLOO ONTARIO
N2L 3G1 CANADA
519-888-4006

RONALD OLSEN
MICROBIOLOGY/IMMUNOLOGY
UNIV OF MICHIGAN
6643 MEDICAL SCIENCE BLDG II
ANN ARBOR MI
481090620
313-763-4380

BETTY H. OLSON
ENVIRON MICROBIOL/GENET
UNIV CALIFORNIA-IRVINE
PROGRAM ON SOCIAL ECOLOGY
IRVINE CA
92717
714-856-7174

BURTON M. POGELL
CTR AGRICULTURAL BIOTECH
UNIV OF MARYLAND
9214 ISPAHAN LOOP
LAURELL MD
20708
301-504-5694

P. H. PRITCHARD
MICROBIAL ECOL/BIOTECHNOL
US ENVIRONMENTAL
PROTECTION AG
BLDG 25/SABINE ISLAND
GULF BREEZE FL
325615299
904-934-9260

RODOLFO QUINTERO-RAMIREZ
CHEM ENGR/INST BIOTECHNOL
AVENIDA UNIVERSIDAD S/N
COLONIA CHAMILPA
CUERNAVACA, MORELOS
62271 MEXICO
527-317-2799

C. ADINARAYANA REDDY
MICROBIOL
MICHIGAN STATE UNIVERSITY
EAST LANSING MI
488241101
517-355-6499

JOHN REEVE
MICROBIOLOGY
OHIO STATE UNIVERSITY
484 W 12TH AVE
COLUMBUS OH
432101292

BARRY P. ROSEN
BIOCHEMISTRY
WAYNE STATE UNIVERSITY
540 E CANFIELD
DETRIOT MI
48201
313-577-1512

EUGENE ROSENBERG
MICROBIOLOGY
TEL AVIV UNIVERSITY
RAMAT-AVIV
69978 ISRAEL

GARY S. SAYLER
CTR FOR ENVIRON BIOTECHN
UNIV OF TENNESSEE
10515 RESEARCH DRIVE STE 100
KNOXVILLE TN
37932
615-675-9450

SIMON D. SILVER
MICROBIOLOGY & IMMUNOLOGY
UNIV OF ILLINOIS
MC 790/BOX 6998/MED CTR
CHICAGO IL
60680
312-996-7470

JOSEPH M. SUFLITA
BOTANY MICRO
UNIV OF OKLAHOMA
770 VAN VLEET OVAL
NORMAN OK
73019
405-325-5734

ANNE O. SUMMERS
MICROBIOLOGY
UNIV OF GEORGIA
261 BIOLOGICAL SCI BLDG
ATHENS GA
30602
404-542-2669

JAMES M. TIEDJE
CROP & SOIL SCI
MICHIGAN STATE UNIVERSITY
SCIENCE
EAST LANSING MI
48824
517-353-9021

RONALD UNTERMAN
RSCH & DEVEL
ENVIROGEN INC
4100 QUAKERBRIDGE ROAD
LAWRENCEVILLE NJ
08648
609-936-9300

JAMES J. VALDES
ERDEC/ATTN SCBRD-RT
U S ARMY
APG MD
ABERDEEN PROVING GROUND
MD
210105423
410-671-1396

BERNARD WITHOLT
BIOTECHNOLOGY
ETH OTHECH CENTER
HONGGERBERG, HPT
ZURICH
CH-8093 SWITZERLAND
411-377-2088

PARTICIPANTS

ROGER A. ACEY
CHEMISTRY/BIOCHEMISTRY
CALIFORNIA STATE UNIVERSITY
1250 BELLFLOWER
LONG BEACH CA
90840
310-498-4945

BRUCE N. ANDERSON
TECHNOLOGY GROUP
ICI AUSTRALIA
1 NICHOLSON STREET
MELBOURNE VICTORIA
3000 AUSTRALIA
613-665-7727

GEORGE P. ANDERSON
CTR BIO/MOLEC SCI & ENGIN
NAVAL RESEARCH LABORATORY
4555 OVERLOOK AVE SW
WASHINGTON DC
20375
202-767-2531

PEGGY J. ARPS
INST OF ARCTIC BIOLOGY
UNIV OF ALASKA
308 IRVING BLDG
FAIRBANKS AK
997750180
907-474-6136

HELMUT BACHMAYER
CORPORATE BIOSAFETY
SANDOZ RESEARCH INSTITUTE
BRUNNERSTRASSE 59
VIENNA
A-1235 AUSTRIA
8-663-4227

MIRA BAGDASARIAN
MICROBIOLOGY
MICHIGAN STATE UNIVERSITY
S-110 PLANT BIOLOGY
EAST LANSING MI
48824
517-353-8619

DAVID P. BALLOU
BIOLOGICAL CHEMISTRY
UNIV OF MICHIGAN
5420 MED SCI I/BOX 0606
ANN ARBOR MI
481090606
313-764-9582

MATTHEW S. BLOUGH
BIOTECHNOLOGY CENTER
CARNEGIE-MELLON UNIVERSITY
4400 FIFTH AVENUE
PITTSBURGH PA
15213
412-268-3426

V. RENGANATHAN
CHEM & BIOL SCIENCES
OREGON GRAD INST
OF SCI & TECH
19600 NW VON NEUMANN DR
BEAVERTON OR
970061999
503-690-1134

HARRY F. RIDGWAY
BIOTECHNOLOGY RESEARCH
ORANGE COUNTY
WATER DISTRICT
10500 ELLIS AVENUE
FOUNTAIN VALLEY CA
927288300
714-378-3266

DEBORAH J. ROBERTS
CIVIL ENVIRONMENTAL ENG
UNIV OF HOUSTON
HOUSTON TX
772044791
713-743-4281

PAUL R. ROSEVEAR
BIOCHEM/MOLEC BIOL/HSCH
UNIV OF TEXAS
PO BOX 20708/6431 FANNIN
HOUSTON TX
77030
713-792-5600

SIMA SARIASLANI
CR&D
E I DU PONT
EXPERIMENTAL STATION
WILMINGTON DE
198800228
302-695-7425

JEREMY D. SEMRAU
ENVIRON ENGINEERING SCI
CALIFORNIA INST OF
TECHNOLOGY
MK LABS 138-78
PASADENA CA
91125
818-356-2994

MANISH M. SHAH
BIOTECHNOLOGY CENTER
UTAH STATE UNIVERSITY
BIOTECH 105
LOGAN UT
843224705
801-750-2730

JODI R. SHANN
ML#6
UNIV OF CINCINNATI
CINCINNATI OH
452190006
513-556-8265

KELLY S. SMITH
ENVIRON ENG SCI
CALIFORNIA INST OF
TECHNOLOGY
MAIL CODE 138-78
PASADENA CA
91125
818-356-2994

MARILYN K. SPEEDIE
BIOMEDICAL CHEMISTRY
UNIV OF MARYLAND
20 N PINE ST
BALTIMORE MD
21201
301-328-7541

BRENDA S. SPEER
BMMB
UNIV OF MAINE
185 HITCHNER HALL
ORONO ME
044695735
207-581-2803

KAILASH C. SRIVASTAVA
ARCHTECH INC
14100 PARK MEADOW DR
CHANTILLY VA
22021
703-222-0280

JOHN STENSTROM
MICROBIOLOGY
SWEDISH UNIVERSITY
BOX 7025
UPPSALA
S-750 07 SWEDEN

YUICHI SUWA
CTR FOR MICROBIAL ENCOL
MICHIGAN STATE UNIVERSITY
EAST LANSING MI
48824
517-336-3771

WILLIAM C. TACON
MOLECULAR/MICROBIOL TECH
BATTELLE
505 KING AVENUE
COLUMBUS OH
432012693
614-424-4483

HAI-MENG TAN
MICROBIOLOGY
NATIONAL UNIV OF SINGAPORE
LOWER KENT RIDGE RD
SINGAPORE
0511 SINGAPORE
65-772-6407

PAUL H. TOMASEK
FOOD SCIENCES
RUTGERS UNIVERSITY
PO BOX 231
NEW BRUNSWICK NJ
08903

EDYE C. UDELL
ENVIRON ENGINEERING SCI
CALIFORNIA INST OF
TECHNOLOGY
138-78
PASADENA CA
91125
818-356-2994

JUDY D. WALL
BIOCHEMISTRY
UNIV OF MISSOURI
117 SCHWEITZER HALL
COLUMBIA MO
65211
314-882-8726

THOMAS K. WOOD
BIOCHEM ENGINEERING
UNIV CALIFORNIA-IRVINE
516 ENGR BLDG
IRVINE CA
92717
714-725-3147

GERBEN J. ZYLSTRA
AGBIOTECH CENTER
RUTGERS UNIVERSITY
COLLEGE FARM RD/PO BOX 231
NEW BRUNSWICK NJ
089030231
908-932-1044

OFFICE OF THE UNDER SECRETARY OF DEFENSE (ACQUISITION)
DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22304-6145

IN REPLY REFER TO DTIC-OCC

SUBJECT: Distribution Statements on Technical Documents

TO: OFFICE OF NAVAL RESEARCH
CORPORATE PROGRAMS DIVISION
ONR 353
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

1995 1037 007

1. Reference: DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 Mar 87.

2. The Defense Technical Information Center received the enclosed report (referenced below) which is not marked in accordance with the above reference.

FINAL REPORT
N00014-93-1-0198
TITLE: ENVIRONMENTAL
BIOREMEDIATION AND
BIODEGREDATION

3. We request the appropriate distribution statement be assigned and the report returned to DTIC within 5 working days.

4. Approved distribution statements are listed on the reverse of this letter. If you have any questions regarding these statements, call DTIC's Cataloging Branch, (703) 274-6837.

FOR THE ADMINISTRATOR:

1 Encl

GOPALAKRISHNAN NAIR
Chief, Cataloging Branch

FL-171
Jul 93

DISTRIBUTION STATEMENT A:

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

DISTRIBUTION STATEMENT B:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES ONLY; (Indicate Reason and Date Below). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT C:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND THEIR CONTRACTORS; (Indicate Reason and Date Below). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT D:

DISTRIBUTION AUTHORIZED TO DOD AND U.S. DOD CONTRACTORS ONLY; (Indicate Reason and Date Below). OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT E:

DISTRIBUTION AUTHORIZED TO DOD COMPONENTS ONLY; (Indicate Reason and Date Below). OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office Below).

DISTRIBUTION STATEMENT F:

FURTHER DISSEMINATION ONLY AS DIRECTED BY (Indicate Controlling DoD Office and Date Below) or HIGHER DOD AUTHORITY.

DISTRIBUTION STATEMENT X:

DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND PRIVATE INDIVIDUALS OR ENTERPRISES ELIGIBLE TO OBTAIN EXPORT-CONTROLLED TECHNICAL DATA IN ACCORDANCE WITH DOD DIRECTIVE 5230.25, WITHHOLDING OF UNCLASSIFIED TECHNICAL DATA FROM PUBLIC DISCLOSURE, 6 Nov 1984 (Indicate date of determination). CONTROLLING DOD OFFICE IS (Indicate Controlling DoD Office).

The cited documents has been reviewed by competent authority and the following distribution statement is hereby authorized.

A

(Statement)

OFFICE OF NAVAL RESEARCH
CORPORATE PROGRAMS DIVISION
ONR 353
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

(Controlling DoD Office Name)

(Reason)

(Controlling DoD Office Address, City, State, Zip)

DEBRA T. HUGHES
DEPUTY DIRECTOR
CORPORATE PROGRAMS OFFICE

(Signature & Typed Name)

(Assigning Office)

19 SEP 1995

(Date Statement Assigned)