Publications of the Exobiology Program for 1986

A Special Bibliography

The George Washington University
Washington, D.C.

and

NASA Office of Space Science and Applications
Washington, D.C.
**TABLE OF CONTENTS**

INTRODUCTION ...................................................... 1

COSMIC EVOLUTION OF BIogenic COMPOUNDS ......................... 5

PREBIOTIC EVOLUTION .................................................. 13

EARLY EVOLUTION OF LIFE .............................................. 25

EVOLUTION OF ADVANCED LIFE ........................................... 35

SOLAR SYSTEM EXPLORATION .......................................... 39

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI) ............... 45

ERRATUM ........................................................................ 51

APPENDIX: Program Participants ....................................... 54
The Exobiology Program, within the Office of Space Science and Applications of the National Aeronautics and Space Administration, is an integrated program to investigate those processes that may have been responsible for or related to the origin, evolution, and distribution of life in the universe.

This report contains a listing of 1986 publications resulting from research supported by the Exobiology Program. Our intent in compiling this report is twofold: We want to provide the scientific community with an annual publication listing (as we have done since 1975) of current NASA-supported research in this field, and we hope to stimulate the exchange of information and ideas among scientists working in the different areas of the program.

Research supported by the Exobiology Program is explored in the areas of \textit{Cosmic Evolution of Biogenic Compounds}, \textit{Prebiotic Evolution}, \textit{Early Evolution of Life}, and \textit{Evolution of Advanced Life}. Pre-mission and pre-project activities supporting these areas are supported in the areas of \textit{Solar System Exploration} and \textit{Search for Extraterrestrial Intelligence}.

\textbf{EACH AREA IS DEFINED AS FOLLOWS:}

\textbf{COSMIC EVOLUTION OF BIOGENIC COMPOUNDS} focuses on the history of the biogenic elements (C,H,N,O,P,S) and their compounds in the galaxy and the early solar system. This includes: (1) tracing the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determining the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system and the prebiotic evolution and origin of life; (3) determining the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies.

\textbf{PREBIOTIC EVOLUTION} involves research and analysis in two major areas: (1) the consequences of planetary evolution on the physical environments of the Earth and planets, and (2) the evolution of molecules and molecular systems under the constraints imposed by physical environment and the appearance, a posteriori, of living systems on Earth. It also assesses the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces.

\textbf{EARLY EVOLUTION OF LIFE} focuses on the nature of the most primitive organisms, determining the environment in which they evolved, and the way in which they influenced that environment. Investigations are executed through the use of the molecular record in living organisms and the geological record in rocks. These records are used to determine when and in what setting life first appeared; to determine the characteristics of the first successful
living organisms; to understand the phylogeny and physiology of microorganisms that inhabit hydrothermal areas now thought to be analogs of primitive environments; to determine the original nature of biotic energy transduction, membrane function, and information processing through study of extant microbes; and to elucidate the physical, chemical, and biotic forces operating on microbial evolution.

**EVOLUTION OF ADVANCED LIFE** examines the influence of astrophysical, stellar and solar system events on the evolution of advanced life on Earth. Research in this area also attempts to develop a program plan for a paleontological data base; to understand possible evolutionary pathways for advanced life; and to investigate ancient atmospheres.

**SOLAR SYSTEM EXPLORATION** focuses on providing specific information on the elemental and chemical composition, mainly in respect to gases and volatiles, of the atmospheres and surfaces of solar system bodies, including planets and their satellites, comets, asteroids, meteorites, and dust in space. Improved methods, instrumentation, and experiments will be developed for in situ chemical analyses of the volatile species associated with the bodies to be investigated.

**SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)** involves the search for extraterrestrial intelligent life by detecting signals in the electromagnetic spectrum. Principal emphasis has been on technology development for the microwave observing project.

This bibliography is divided into the six areas noted above. Within each research area, references are listed alphabetically by author. Authors who are principal investigators are identified by an asterisk. In addition, current addresses for all Principal Investigators are given in the Appendix.

We wish to thank all the participants in the Exobiology Program for their cooperation in responding to our request for a listing of their 1986 publications. We also wish to thank Janice Susan Wallace for her editorial and technical assistance and John Bourdeau and Janet Vaughn Powers for their technical assistance.

John D. Rummel  
Exobiology Program Manager  
December 1987
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
ARONOWITZ, S.; SCATTERGOOD*, T.; FLORES, J.; CHANG*, S.
HOT HYDROGEN ATOM REACTIONS MODERATED BY H₂ AND He.
JOURNAL OF PHYSICAL CHEMISTRY
90: 1806-1811, 1986. (GWU 7204)

BUNCH*, T.E.; CHANG*, S.; CASSEN, P.; REYNOLDS, R.
ALLENDE: PROFILE OF PARENT BODY GROWTH.
LUNAR AND PLANETARY SCIENCE
XVII: 89-90, 1986. (GWU 7210)

CARR, R.H.; GIBSON*, E.K., JR.; REITMEIJER, F.; GRADY, M.; WRIGHT, I.;
PILLINGER, C.
CHARACTERIZATION OF CARBONACEOUS MATERIAL IN INTERPLANETARY DUST PARTICLES.
METEORITICS
21: 344-345, 1986. (GWU 7653)

CHANG*, S.; BUNCH*, T.E.
CLAYS AND ORGANIC MATTER IN METEORITES.

CRONIN*, J.R.; PIZZARELLO, S.
AMINO ACIDS OF THE MURCHISON METEORITE. III. SEVEN CARBON ACYCLIC PRIMARY
ALPHA-AMINO ALKANOIC ACIDS.
GEOCHIMICA ET COSMOCHIMICA ACTA
50: 2419-2427, 1986. (GWU 7215)

DEFREES*, D.J.; MCLEAN, A.D.
AB INITIO DETERMINATION OF THE PROTON AFFINITIES OF SMALL NEUTRAL AND ANIONIC
MOLECULES.
JOURNAL OF COMPUTATIONAL CHEMISTRY

DEFREES*, D.J.; MCLEAN, A.D.
AB INITIO MOLECULAR ORBITAL STUDIES OF LOW-ENERGY, METASTABLE ISOMERS OF THE
UBIQUITOUS CYCLOPROPENYLDENE.
ASTROPHYSICAL JOURNAL

DEFREES*, D.J.; BINKLEY, J.S.; FRISCH, M.J.; MCLEAN, A.D
IS N-PROTONATED HYDROGEN ISOCYANIDE, H₂NC⁺, AN OBSERVABLE INTERSTELLAR SPECIES?
JOURNAL OF CHEMICAL PHYSICS
85(9): 5194-5199, 1986. (GWU 7220)
DEFREES*, D.J.; MCLEAN, A.D.
A PRIORI PREDICTIONS OF THE ROTATIONAL CONSTANTS FOR PROTONATED FORMALDEHYDE AND PROTONATED METHANOL.
CHEMICAL PHYSICS LETTERS
131(4,5): 403-408, 1986. (GWU 7221)

(CHANG, S. = P.I.)
THE EMISSION OF ATOMS AND MOLECULES ACCOMPANYING FRACTURE OF SINGLE-CRYSTAL MgO.
JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY

FREUND, F.; CHANG*, S.; PINEAU, F.; KNOBEL, R.M.; STRUWE, F.
FORMATION OF ORGANIC COMPOUNDS AND CO₂ SEGREGATION OF CARBON FROM MgO - KINETIC AND ISOTOPIC DATA.
ORIGINS OF LIFE
16(3-4): 289-290, 1986. (GWU 7235)

ORGANIC MOLECULES RELEASED FROM OLIVINE BY IMPACT FRACTURE.
ORIGINS OF LIFE
16(3-4): 291-292, 1986. (GWU 7236)

FRIBERG, P.; IRVINE*, W.M.; MADDEN, S.C.; HJALMARSON, A.
STUDIES OF ORGANIC MOLECULES CONTAINING METHYL GROUPS IN DARK CLOUDS.
IN: ASTROCHEMISTRY (VARDYA, M.S.; TARAFDAR, S.P., EDS.).

GIBSON*, E.K., JR.; SOMMER, M.
LASER MICROPROBE STUDY OF COSMIC DUST (IDPs) AND POTENTIAL SOURCE MATERIALS.
LUNAR AND PLANETARY SCIENCE
XVII: 260-261, 1986. (GWU 7655)

GIBSON*, E.K., JR.; SOMMER, M.
LASER MICROPROBE STUDY OF COSMIC DUST (IDPs). TRAJECTORY DETERMINATIONS AND COLLECTION OF MICROMETEOROIDS ON THE SPACE STATION.
IN: LPI TECHNICAL REPORT 86-05, P. 56-57, 1986. (GWU 7656)

GOLDSMITH, P.F.; IRVINE*, W.M.; HJALMARSON, A.; ELLDER, J.
VARIATIONS IN THE HCN/HNC ABUNDANCE RATIO IN THE ORION MOLECULAR CLOUD.
ASTROPHYSICAL JOURNAL
IRVINE*, W.M.
THE CHEMISTRY OF COLD, DARK INTERSTELLAR CLOUDS.
IN: ASTROCHEMISTRY (VARDYA, M.S., TARAFDAR, S.P., EDS.).

JARROLD, M.F.; BOWERS, M.T.; DeFREES*, D.J.; MCLEAN, A.D.; HERBST, E.
A REANALYSIS OF THE HCO+/HOC+ ABUNDANCE RATIO IN DENSE INTERSTELLAR CLOUDS.
ASTROPHYSICAL JOURNAL
303(1): 392-400, 1986. (GWU 7512)

AMMONIA MASERS DETECTED IN STAR FORMING REGIONS.
IN: MASERS, MOLECULES AND MASS OUTFLOWS IN STAR FORMING REGIONS
(HASCHICK, A.D., ED.).

MADDEN, S.C.; IRVINE*, W.M.; MATTHEWS, H.E.
DETECTIONS OF 13C-SUBSTITUTED C_3H_2 IN ASTRONOMICAL SOURCES.
ASTROPHYSICAL JOURNAL

MADDEN, S.C.; IRVINE*, W.M.; MATTHEWS, H.E.; AVERY, L.W.
MULTI-LEVEL STUDY OF C_3H_2: THE FIRST INTERSTELLAR HYDROCARBON RING.
IN: SUMMER SCHOOL ON INTERSTELLAR PROCESSES (HOLLENBACH, D., THRONSON, H., EDS.).
(GWU 7547)

NEW INTERSTELLAR MASERS IN NONMETASTABLE AMMONIA.
ASTROPHYSICAL JOURNAL
300(2): L79-L84, 1986. (GWU 7548)

MATTHEWS, H.E.; MADDEN, S.C.; AVERY, L.W.; IRVINE*, W.M.
THE C_3H_2 220-211 TRANSITION: ABSORPTION IN COLD DARK CLOUDS.
ASTROPHYSICAL JOURNAL

MATTHEWS, H.E.; IRVINE*, W.M.
OBSERVATIONS OF THE HYDROCARBON RING C_3H_2.
IN: MASERS, MOLECULES AND MASS OUTFLOWS IN STAR FORMING REGIONS
(HASCHICK, A.D., ED.).
CAMBRIDGE, MA: HAYSTACK OBSERVATORY, P. 1-8, 1986. (GWU 7555)
SCHLOERB, F.P.; SNELL, R.L.; GOLDSMITH, P.F.; MORGAN, J.A.  
(IRVINE, W.M. = P.I.)
CO MAPPING OF THE ORION MOLECULAR CLOUD: THE INFLUENCE OF STAR FORMATION ON CLOUD STRUCTURE.
IN: SUMMER SCHOOL ON INTERSTELLAR PROCESSES (HOLLENBACH, D., THRONSON, H., EDS.).
(GWU 7579)

SNELL, R.; MORIARTY-SCHIEVEN, G.; STROM, S.; SCHLOERB, P.; STROM, K.; GRASDALEN, G.  
(IRVINE, W.M. = P.I.)
HIGH RESOLUTION OBSERVATIONS OF THE L1551 BIPOLAR OUTFLOW.
IN: SUMMER SCHOOL ON INTERSTELLAR PROCESSES (HOLLENBACH, D., THRONSON, H., EDS.).
(GWU 7584)

WOOTTEN, A.; BOULANGER, F.; BOGEY, M.; COMBES, F.; ENCRENAZ, P.J.; GERIN, M.; ZIURYS, L.  
(IRVINE, W.M. = P.I.)
A SEARCH FOR INTERSTELLAR H$_3$O$^+$.  
ASTRONOMY AND ASTROPHYSICS 166: L15-L18, 1986. (GWU 7608)

ZIURYS, L.M.; TURNER, B.E.  
(IRVINE, W.M. = P.I.)
DETECTION OF VIBRATIONALLY EXCITED HCN IN ORION-KL AND IRC$^+$10216.  
IN: MASERS, MOLECULES AND MASS OUTFLOWS IN STAR FORMING REGIONS
HASCHICK, A.D., ED.).  
CAMBRIDGE, MA: HAYSTACK OBSERVATORY, P. 23-29, 1986. (GWU 7609)

ZIURYS, L.M.; TURNER, B.E.  
(IRVINE, W.M. = P.I.)
DETECTION OF INTERSTELLAR VIBRATIONALLY EXCITED HCN.  

ZIURYS, L.M.; TURNER, B.E.  
(IRVINE, W.M. = P.I.)
HCN+ : A NEW INTERSTELLAR MOLECULAR ION.  

ZIURYS, L.M.; TURNER, B.E.  
(IRVINE, W.M. = P.I.)
NEW INTERSTELLAR MOLECULAR DETECTIONS: IMPLICATIONS FOR "SHOCK CHEMISTRY."
IN: ASTROCHEMISTRY (VARDYA, M.S., TARAFDAR, S.P., EDS.).
ZIURYS, L.M.; SNELL, R.L.; ERICKSON, N.R. (IRVINE, W.M. = P.I.)
STUDIES OF INTERSTELLAR VIBRATIONALLY-EXCITED MOLECULES.
IN: SUMMER SCHOOL ON INTERSTELLAR PROCESSES (HOLLENBACH, D., THRONSON, H., EDS.).
PREBIOTIC EVOLUTION
ACEVEDO, O.L.; ORGEL*, L.E.
TEMPLATE-DIRECTED OLIGONUCLEOTIDE LIGATION ON HYDROXYLAPATITE.
NATURE
321: 790-792, 1986. (GWU 7201)

OPTICAL CONSTANTS OF BASALTIC GLASS FROM 0.0173 TO 50 µM (ABSTRACT).
BULLETIN OF THE AMERICAN ASTRONOMICAL SOCIETY
18(3): 777, 1986. (GWU 7202)

REFRACTIVE INDICES OF LIQUID METHANE AND ETHANE (ABSTRACT).
BULLETIN OF THE AMERICAN PHYSICAL SOCIETY
31(3): 700, 1986. (GWU 7203)

REMARKS ON THE REVIEW ARTICLE "REPLICATION AND EVOLUTION IN INORGANIC SYSTEMS" BY ARMIN WEISS.
ANGEWANDTE CHEMIE, INTERNATIONAL EDITION IN ENGLISH
25: 658, 1986. (GWU 7205)

BASILE, B.; MIDDLEDITCH, B.S.; ORO*, J.
The origin of polynuclear aromatic hydrocarbons in the Murchison Meteorite (ABSTRACT).
IN: 1986 SOUTHWEST REGIONAL MEETING, AMERICAN CHEMICAL SOCIETY, HOUSTON, TX, NOVEMBER 19-21, P. 58, 1986. (GWU 7628)

RAMAN SPECTRA OF SINGLE CRYSTALS OF R(GCG)D(CGC) AND (CCCCGGGG) AS MODELS FOR A DNA, THEIR STRUCTURE TRANSITIONS IN AQUEOUS SOLUTION, AND COMPARISON WITH DOUBLE HELICAL POLY(dG) POLY(dC).
BIOCHEMISTRY

BERRY, J.; ORO*, J.
RESULTS FROM HALLEY'S COMET: IMPLICATIONS FOR THE ORIGIN OF LIFE (ABSTRACT).
IN: 1986 SOUTHWEST REGIONAL MEETING, AMERICAN CHEMICAL SOCIETY, HOUSTON, TX, NOVEMBER 19-21, P. 59, 1986. (GWU 7629)
BHADRA, A.; PONNAMPERUMA*, C.
THE ROLE OF SULFUR IN PREBIOTIC CHEMISTRY.
ORIGINS OF LIFE
16(3-4): 287, 1986. (GWU 7630)

CHAN, S.; ORENBERG*, J.B.; LAHAV*, N.
SOLUBLE MINERALS IN CHEMICAL EVOLUTION. II. CHARACTERIZATION OF THE ADSORPTION OF 5'-AMP AND 5'-CMP ON A VARIETY OF SOLUBLE MINERAL SALTS.
ORIGINS OF LIFE
17: 22-35, 1986. (GWU 7631)

COLL, M.; WANG, A.H.-J.; van der MAREL, G.A.; van BOOM, J.H.; RICH*, A.
CRYSTAL STRUCTURE OF A Z-DNA FRAGMENT CONTAINING THYMINE/2-AMINOADENINE BASE PAIRS.
JOURNAL OF BIOMOLECULAR STRUCTURE AND FUNCTION
4: 157-172, 1986. (GWU 7632)

COYNE*, L.M.
CLAY ENERGETICS IN CHEMICAL EVOLUTION - SOLVATION/DESOLVATION LUMINESCENCE OF SOME ARTIFICIALLY AND NATURALLY HYDRATED KAOLINS.
ORIGINS OF LIFE

COYNE*, L.M.; BANIN*, A.
EFFECT OF ADSORBED IRON ON THERMOLUMINESCENCE AND ELECTRON SPIN RESONANCE SPECTRA OF Ca-Fe-EXCHANGED MONTMORILLONITE.
CLAYS AND CLAY MINERALS
34(6): 645-650, 1986. (GWU 7214)

MULTIPLE BIOLOGICAL ACTIVITIES OF HUMAN RECOMBINANT INTERLEUKIN 1.
JOURNAL OF CLINICAL INVESTIGATION

AN ASSESSMENT OF THE Z-DNA FORMING POTENTIAL OF ALTERNATING dA-dT STRETCHES IN SUPERCOILED PLASMIDS.
BIOCHEMISTRY
25(12): 3648-3655, 1986. (GWU 7227)

FERRIS*, J.P.; HAGAN, W.J., JR.
THE ADSORPTION AND REACTION OF ADENINE NUCLEOTIDES ON MONTMORILLONITE.
ORIGINS OF LIFE
17: 69-84, 1986. (GWU 7229)
FERRIS*, J.P.; HUANG, C-H.; HAGAN, W.J., JR.
CLAYS AS PROTOTYPICAL ENZYMES FOR THE PREBIOLOGICAL FORMATION OF PHOSPHATE ESTERS.
ORIGINS OF LIFE
16(3-4): 473-474, 1986. (GWU 7230)

FOX*, S.W.
DETERMINISTIC SELFORGANIZATION IN EVOLUTION.
IN: SELFORGANIZATION (FOX, S.W., EDS.)

FOX*, S.W.;
THE EVOLUTIONARY SEQUENCE: ORIGIN AND EMERGENCES.
AMERICAN BIOLOGY TEACHER
48(3): 140-169, 1986. (GWU 7232)

FOX*, S.W.
MOLECULAR SELECTION AND NATURAL SELECTION.
QUARTERLY REVIEW OF BIOLOGY
61(3): 375-385, 1986. (GWU 7233)

FOX*, S.W.
MOLECULAR SELECTION IN A UNIFIED EVOLUTIONARY SEQUENCE.
INTERNATIONAL JOURNAL OF QUANTUM CHEMISTRY: QUANTUM BIOLOGY SYMPOSIUM

GARAVELLI, J.S.; WEBER*, A.L.
COMPUTER MODEL OF A POLYRIBONUCLEOTIDE STRUCTURE WHICH MAY HAVE FUNCTIONED AS A CATALYTIC ADAPTOR FOR PEPTIDE BOND SYNTHESIS.
ORIGINS OF LIFE
16(3-4): 522, 1986. (GWU 7497)

GOLDBLUM, A.; KIEBER-EMMONS, T.; REIN*, R.
AN IMPROVED APPROACH TO THE ANALYSIS OF DRUG-PROTEIN BINDING BY DISTANCE GEOMETRY.
JOURNAL OF MOLECULAR STRUCTURE

HARTMAN*, H.; VICHNIAC, G.Y.
INHOMOGENEOUS CELLULAR AUTOMATA.
IN: DISORDERED SYSTEMS AND BIOLOGICAL ORGANIZATION (E. BIENESTOCK, F. FOGELMAN, G. WEISBUCH, EDS.)
BERLIN, W. GERMANY: SPRINGER VERLAG, P. 53-57, 1986. (GWU 7551)
HO, M.-W.; SAUNDERS, P.; FOX*, S.
A NEW PARADIGM FOR EVOLUTION.
NEW SCIENTIST

HO, P.S.; ELLISON, M.J.; QUIGLEY, G.J.; RICH*, A.
A COMPUTER AIDED THERMODYNAMIC APPROACH FOR PREDICTING THE FORMATION OF Z-DNA IN NATURALLY OCCURRING SEQUENCES.
EMBO JOURNAL
5: 2737-2744, 1986. (GWU 7664)

LOCAL MOBILITY OF NUCLEIC ACIDS AS DETERMINED FROM CRYSTALLOGRAPHIC DATA.
JOURNAL OF MOLECULAR BIOLOGY

HOLLAND*, H.D.; LAZAR, B.; MCCAFFREY, M.
EVOLUTION OF THE ATMOSPHERE AND OCEANS.
NATURE
320(6057): 27-33, 1986. (GWU 7515)

HUA, L.-L.; KOBAYASHI, K.; OCHIAI, E.-I.; GEHRKE, C.W.; GERHARDT, L.O.; PONNAMPERUMA*, C.
IDENTIFICATION AND QUANTIFICATION OF NUCLEIC ACID BASES IN CARBONACEOUS CHONDRITES.
ORIGINS OF LIFE
16(3-4): 226-227, 1986. (GWU 7634)

JOYCE, G.F.; ORGEL*, L.E.; MILLER*, S.L.
CHIRAL SELECTION IN TEMPLATE-DIRECTED RNA SYNTHESIS AND THE CASE FOR A PROCHIRAL ANCESTOR OF RNA (ABSTRACT).
ORIGINS OF LIFE
16(3-4): 445, 1986. (GWU 7516)

JOYCE, G.F.; ORGEL*, L.E.
NON-ENZYMIC TEMPLATE-DIRECTED SYNTHESIS ON RNA RANDOM COPOLYMERS.
JOURNAL OF MOLECULAR BIOLOGY
188: 433-441, 1986. (GWU 7521)

KANAVARIOTI, A. (WHITE, D.H. = P.I.)
KINETICS OF THE HYDROLYSIS OF GUanosINE 5'-PHOSPHO-2-METHYLMIDAZOLOIDE.
ORIGINS OF LIFE
17: 85-103, 1986. (GWU 7522)

KELLEHER, R.J., III.; ELLISON, M.J.; HO, P.S.; RICH*, A.
COMPETITVE BEHAVIOR OF MULTIPLE, DISCRETE B-Z TRANSITIONS IN SUPERCOILED DNA.
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, USA
83: 6342-6346, 1986. (GWU 7526)
KERRIDGE*, J.F.; SHIPP, R.; CHANG*, S.
DEUTERIUM EXCHANGE DURING ACID-DEMINERALISATION.
LUNAR AND PLANETARY SCIENCE
XVII: 414-415, 1986. (GWU 7527)

RATIONAL DESIGN AND APPLICATION OF IDIOTOPE VACCINES.
INTERNATIONAL REVIEWS IN IMMUNOLOGY
1: 1-26, 1986. (GWU 7530)

KOBAYASHI, K.; HUA, L.-L.; KNAACK, M.; GEHRKE, C.W.; GERHARDT, K.O.;
PONNAMPERUMA*, C.
ABIOTIC SYNTHESIS OF BIO-ORGANIC COMPOUNDS BY SPARK DISCHARGE IN SIMULATED
PRIMITIVE EARTH ATMOSPHERES.
IN: ABSTRACTS OF PAPERS, 192ND AMERICAN CHEMICAL SOCIETY MEETING, ANAHEIM, CA,
P. 154, 1986. (GWU 7635)

KOBAYASHI, K.; WANG, W.; ZHAO, N.; PONNAMPERUMA*, C.
ELECTRIC DISCHARGE REACTIONS IN A MIXTURE OF PHOSPHINE, METHANE,
NITROGEN AND WATER.
ORIGINS OF LIFE
16(3-4): 230-231, 1986. (GWU 7636)

KOBAYASHI, K.; HUA, L.-L.; GEHRKE, C.W.; GERHARDT, K.O.;
PONNAMPERUMA*, C.
ABIOTIC SYNTHESIS OF NUCLEIC ACID BASES BY ELECTRIC DISCHARGE IN A SIMULATED
PRIMITIVE ATMOSPHERE.
ORIGINS OF LIFE
16(3-4): 299-300,1986. (GWU 7637)

ABIOTIC SYNTHESIS OF NUCLEOSIDES BY ELECTRIC DISCHARGE IN A SIMULATED PRIMITIVE
EARTH ATMOSPHERE.
ORIGINS OF LIFE
16(3-4): 277-278, 1986. (GWU 7638)

KWIAKTOWSKI, J.S.; ZIELINSKI, T.J.; REIN*, R.
QUANTUM-MECHANICAL PREDICTION OF TAUTOMERIC EQUILIBRIA.
ADVANCES IN QUANTUM CHEMISTRY
18: 85-130, 1986. (GWU 7536)

LACEY*, J.C., JR.; MULLINS, D.W., JR.; WATKINS, C.L.
ALIPHATIC AMINO ACID SIDE CHAINS ASSOCIATE WITH THE "FACE" OF THE ADENINE RING.
JOURNAL OF BIOMOLECULAR STRUCTURE AND DYNAMICS
3(4): 783-793, 1986. (GWU 7537)
LAFER, E.M.; SOUSA, R.; ALI, R.; RICH*, A.; STOLLAR, B.D.
THE EFFECT OF ANTI-Z-DNA ANTIBODIES ON THE B-DNA-Z-DNA EQUILIBRIUM.
JOURNAL OF BIOLOGICAL CHEMISTRY
261(14):6438-6443, 1986. (GWU 7538)

LAWLESS, J.G. (WHITE, D.H. = P.I.)
CLAY-ORGANIC INTERACTIONS AND THE ORIGIN OF LIFE.
IN: CLAY MINERALS AND THE ORIGIN OF LIFE (CAIRNS-SMITH, A.G.;
HARTMAN, H., EDS.).
CAMBRIDGE, ENGLAND: CAMBRIDGE UNIVERSITY PRESS, P.135-137, 1986. (GWU 7540)

LEVINE*, J.S.
THE EARLY ATMOSPHERE: A NEW PICTURE.
SCIENCE ACTIVITIES
FEBRUARY/MARCH: 7-16, 1986. (GWU 7541)

THEORETICAL INVESTIGATIONS OF THE ROLE OF CLAY EDGES IN PREBIOTIC PEPTIDE BOND
FORMATION. 2. STRUCTURE AND ELECTRON DISTRIBUTION OF ACTIVATED AMINO ACID ESTERS.
ORIGINS OF LIFE
16(3-4): 471-472, 1986. (GWU 7544)

MAR, A.; ORO*, J.
PREBIOTIC SYNTHESIS AND SEPARATION OF PHOSPHORYLATED METABOLIC INTERMEDIATES
(ABSTRACT).
IN: 1986 SOUTHWEST REGIONAL MEETING, AMERICAN CHEMICAL SOCIETY, HOUSTON, TX,
NOVEMBER 19-21, P. 59, 1986. (GWU 7639)

MILLER*, S.L.
CURRENT STATUS OF THE PREBIOTIC SYNTHESIS OF SMALL MOLECULES.
CHEMICA SCRIPTA
26B: 5-11, 1986. (GWU 7560)

MULLINS, D.W., JR.; LACEY*, J.C., JR.
COMPARATIVE RATES OF ESTERIFICATION OF 5'-AMP WITH HYDROPHOBIC AMINO ACIDS:
RELEVANCE TO THE GENETIC-CODE ASSIGNMENTS.
JOURNAL OF MOLECULAR EVOLUTION
23: 76-79, 1986. (GWU 7561)

NAKASHIMA, T. (FOX, S.W. = P.I.)
METABOLISM OF PROTEINOID MICROSPHERES.
TOPICS IN CURRENT CHEMISTRY
139: 57-81, 1986. (GWU 7562)
NAVARRO-GONZALEZ, R.; NEGRON-MENDOZA, A.; PONNAMPERUMA*, C.
METHANE AS A CHEMICAL DOSIMETER IN PREBIOTIC EXPERIMENTS. I. ELECTRICAL DISCHARGE, HEAT, AND SHOCK WAVES.
ORIGINS OF LIFE
16(3-4): 301-302, 1986. (GWU 7640)

NEGRON-MENDOZA, A.; NAVARRO-GONZALEZ, R.; PONNAMPERUMA*, C.
INFLUENCE OF Na-MONTMORILLONITE IN THE GAMMA RADIOLYSIS OF ACETIC ACID.
ORIGINS OF LIFE
16(3-4): 303-304, 1986. (GWU 7641)

ANALYSIS OF Z-DNA IN FIXED POLYTENE CHROMOSOMES WITH MONOCLONAL ANTIBODIES THAT SHOW BASE SEQUENCE-DEPENDENT SELECTIVITY IN REACTIONS WITH SUPERCOILED PLASMIDS AND POLYNUCLEOTIDES.
JOURNAL OF BIOLOGICAL CHEMISTRY

BIOQUIMICA Y BIOLOGIA MOLECULAR.
BARCELONA, SPAIN: EDITORIAL SALVAT, 586 P., 1986. (GWU 7642)

ORGEL*, L.E.
RNA CATALYSIS AND THE ORIGINS OF LIFE.
JOURNAL OF THEORETICAL BIOLOGY
123: 127-149, 1986. (GWU 7565)

ORGEL*, L.E.

ORGEL*, L.
DID TEMPLATE-DIRECTED NUCLEATION PRECEDE MOLECULAR REPLICATION?
ORIGINS OF LIFE
17: 27-34, 1986. (GWU 7651)

ORO*, J.
LA EVOLUCION QUIMICA Y EL ORIGEN DE LA VIDA.
ORO*, J.
LA EXPLORACION DEL ESPACIO Y EL ORIGEN DE LA VIDA.
AULA DE CULTURA, EL CORREO ESPANOL-EL PUEBLO VASCO, BILBAO, SPAIN, P. 11-33, 1986. (GWU 7645)

PECK, L.J.; WANG, J.C.; NORDHEIM, A.; RICH*, A.
RATE OF B TO Z STRUCTURAL TRANSITION OF SUPERCOILED DNA.
JOURNAL OF MOLECULAR BIOLOGY
190: 125-127, 1986. (GWU 7566)

POHORILLE, A.; PRATT, L.R. (MACELROY, R.D. = P.I.)
THEORETICAL METHODS FOR OBTAINING FREE ENERGIES OF BIOMOLEULAR EQUILIBRIA IN AQUEOUS SOLUTIONS.
METHODS IN ENZYMOLOGY
127: 64-78, 1986. (GWU 7568)

PRZYBYLSKI, A.T.; FOX*, S.W.
ELECTRICAL PHENOMENA IN PROTEINOID CELLS.
IN: MODERN BIOELECTROCHEMISTRY (GUTMANN, F., KEYZER, H.; EDS.).
NEW YORK: PLENUM PRESS, P. 377-396, 1986. (GWU 7569)

DINARELLO, C.A.; GEHRKE, L.; WOLFF, S.M.; RICH*, A; AURON, P.E.
EXPRESSION OF BIOLOGICALLY ACTIVE HUMAN INTERLEUKIN 1 SUBPEPTIDES BY TRANSFECTED SIMIAN COS CELLS.
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, USA
83: 5243-5246, 1986. (GWU 7573)

SCHLESINGER, G.; MILLER*, S.L.
PREBIOTIC SYNTHESIS OF PANTOIC ACID AND THE OTHER COMPONENTS OF COENZYME A (ABSTRACT).
ORIGINS OF LIFE
16(3-4): 307, 1986. (GWU 7578)

SHEN, C.; YANG, L.; MILLER*, S.L.; ORO*, J.
PREBIOTIC SYNTHESIS OF IMIDAZOLE-4-ACETALDEHYDE, IMIDAZOLE-4/GLYCOL AND IMIDAZOLE-4-ETHANOL.
ORIGINS OF LIFE
16(3-4): 275-276, 1986. (GWU 7583)

SHEN, C.; YANG, L.; MILLER*, S.L.; ORO*, J.
PLAUSIBLE PREBIOTIC SYNTHESIS OF HISTIDINE (ABSTRACT).
IN: 1986 SOUTHWEST REGIONAL MEETING, AMERICAN CHEMICAL SOCIETY, HOUSTON, TX, NOVEMBER 19-21, P. 59, 1986. (GWU 7652)
SRINIVASAN, S.; MCGRODER, D.; SHIBATA, M.; REIN*, R.
MOSES: A COMPUTER GRAPHICS SIMULATION PROGRAM IN REAL TIME.
IN: BIOMOLECULAR STEREODYNAMICS III (SARMA, R.H., SARMA, M.H., EDS.).

SRINIVASAN, S.; RAGHUNATHAN, G.; SHIBATA, M.; REIN*, R.
MULTISTEP MODELING (MSM) OF BIOMOLECULAR STRUCTURE APPLICATION TO THE A-G MISPAIR IN THE B-DNA ENVIRONMENT.
INTERNATIONAL JOURNAL OF QUANTUM CHEMISTRY: QUANTUM BIOLOGY SYMPOSIUM
12: 271-227, 1986. (GWU 7586)

SRINIVASAN, S.; SHIBATA, M.; REIN*, R.
MULTISTEP MODELING OF PROTEIN STRUCTURE: APPLICATION TO BUNGAROTOXIN.
INTERNATIONAL JOURNAL OF QUANTUM CHEMISTRY: QUANTUM BIOLOGY SYMPOSIUM

STIRBLING, R.; MILLER*, S.L.
ENERGY YIELDS FOR THE PRODUCTION OF HCN IN ATMOSPHERES WITH HIGH H₂/CH₄ RATIOS:
IMPlications FOR THE JOVIAN ATMOSPHERE AND THE SOLAR NEBULA (ABSTRACT).
ORIGINS OF LIFE
16(3-4): 213, 1986. (GWU 7588)

STIRBLING, R.; MILLER*, S.L.
ENERGY YIELDS IN THE PREBIOTIC SYNTHESIS OF HYDROGEN CYANIDE AND FORMALDEHYDE.
ORIGINS OF LIFE
16(3-4): 279-280, 1986. (GWU 7589)

THOMPSON, J.B.; ORO*, J.
AMINO ACID ANALYSIS OF 25 SPECIES OF CYANOPHYTA IRRADIATION WITH 60-COBALT
(ABSTRACT).
IN: 1986 SOUTHWEST REGIONAL MEETING, AMERICAN CHEMICAL SOCIETY, HOUSTON, TX,
NOVEMBER 19-21, P. 56, 1986. (GWU 7647)

USHER*, D.A.; NEEDELS, M.C.
THE EVOLUTION OF NUCLEOTIDES.
ADVANCES IN SPACE RESEARCH
6: 29-32, 1986. (GWU 7648)

WALKER*, J.C.G.
GLOBAL GEOCHEMICAL CYCLES OF CARBON, SULFUR AND OXYGEN.
MARINE GEOLOGY
70: 159-174, 1986. (GWU 7618)
WALKER*, J.C.G.
IMPACT EROSION OF PLANETARY ATMOSPHERES.
ICARUS
68: 87-98, 1986. (GWU 7663)

WANG, A.H.-J.; UGHETTO, G.; QUIGLEY, G.J.; RICH*, A.
INTERACTIONS OF QUINOXALINE ANTIBIOTIC AND DNA: THE MOLECULAR STRUCTURE OF A
TRIOSTIN A-d(GCGTACGC) COMPLEX.
JOURNAL OF BIOMOLECULAR STRUCTURE AND DYNAMICS
4: 319-342, 1986. (GWU 7649)

WEBER*, A.L.
MODELS OF GLYCOLYSIS: GLYCERALDEHYDE AS A SOURCE OF ENERGY AND MONOMERS FOR
PREBIOTIC CONDENSATION REACTIONS.
ORIGINS OF LIFE
16(3-4): 365-366, 1986. (GWU 7603)

ZHAO, N.; KOBAYASHI, K.; PONNAMPERUMA*, C.
STUDIES OF POSSIBLE ORGANIC SYNTHESIS IN COMETARY-TYPE MIXTURES (ABSTRACT).
IN: ABSTRACTS OF PAPERS, 192ND AMERICAN CHEMICAL SOCIETY MEETING, ANAHEIM, CA,
P. 72, 1986. (GWU 7650)
EARLY EVOLUTION OF LIFE
BUCHANAN*, B.B.
THE FERREDOXIN/THIOREDOXIN SYSTEM.
IN: THIOREDOXIN AND GLUTAREDOXIN SYSTEMS: STRUCTURE AND FUNCTION
NEW YORK: RAVEN PRESS, P. 233-242, 1986. (GWU 7209)

CHINN, P.C.; PIGIET, V.; FAHEY*, R.C.
DETERMINATION OF THIOL PROTEINS USING MONOBROMOBIMANE LABELING AND
HIGH-PERFORMANCE LIQUID CHROMATOGRAPHIC ANALYSIS: APPLICATION TO
Escherichia coli THIOREDOXIN.
ANALYTICAL BIOCHEMISTRY
159: 143-149, 1986. (GWU 7212)

DES MARAIS*, D.J.
CARBON ABUNDANCE MEASUREMENTS IN OCEANIC BASALTS: THE NEED FOR A
CONSSENSUS.
EARTH AND PLANETARY SCIENCE LETTERS
79: 21-26, 1986. (GWU 7222)

FENTON, S.S.; FAHEY*, R.C.
ANALYSIS OF BIOLOGICAL THIOLS: DETERMINATION OF THIOL COMPONENTS OF
DISULFIDES AND THIOESTERS.
ANALYTICAL BIOCHEMISTRY
154: 34-42, 1986. (GWU 7228)

FRANCHI, I.A.; WRIGHT, I.; GIBSON*, E.K., JR.; PILLINGER, C.
The Laser Microprobe: A Technique for Extracting Carbon, Nitrogen and
Oxygen from Solid Samples for Isotopic Measurements.
JOURNAL OF GEOPHYSICAL RESEARCH
91: D514-D524, 1986. (GWU 7654)

FRY, B.; COX, J.; GEST, H.; HAYES*, J.M.
DISCRIMINATION BETWEEN 34S AND 32S DURING BACTERIAL METABOLISM OF
INORGANIC SULFUR COMPOUNDS.
JOURNAL OF BACTERIOLOGY

FRY, B.; GEST, H.; HAYES*, J.M.
SULFUR ISOTOPE EFFECTS ASSOCIATED WITH PROTONATION OF HS- AND
VOLATILIZATION OF H2S.
CHEMICAL GEOLOGY
58: 253-258, 1986. (GWU 7239)
FRY, B. (HAYES, J.M. & P.I.)
SOURCES OF CARBON AND SULFUR NUTRITION FOR CONSUMERS IN THREE
MEROMICTIC LAKES OF NEW YORK STATE.
*LIMNOLOGY AND OCEANOGRAPHY*

GIBSON*, E.K., JR.; CARR, L.P.; GILMOUR, I.; PILLINGER, C.
EARTH'S ATMOSPHERE DURING THE ARCHEAN AS SEEN FROM CARBON AND NITROGEN
ISOTOPIC ANALYSIS OF SEDIMENTS.
*LUNAR AND PLANETARY SCIENCE*
XVII: 258-259, 1986. (GWU 7657)

MARGULIS*, L.
PREDATORY PROKARYOTES: PREDATION AND PRIMARY CONSUMPTION
EVOLVED IN BACTERIA.
*PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, USA*
83: 2138-2142, 1986. (GWU 7658)

GUTELL, R.R.; NOLLER, H.F.; WOESE*, C.R.
HIGHER ORDER STRUCTURE IN RIBOSOMAL RNA.
*EMBO JOURNAL*

HUPPE, H.C.; BUCHANAN*, B.B.
STUDIES ON THE EVOLUTION OF THIOREDOXINS: PROPERTIES OF THIOREDOXINS \( \alpha \) AND
\( \beta \) IN A PHOTOTROPHICALLY AND HETEROTROPHICALLY GROWN GREEN ALGA.
*ORIGINS OF LIFE*
16(3-4): 258-259, 1986. (GWU 7507)

JACKSON, J.; HUPPE, H.C.; JOHNSON, T.C.; BUCHANAN*, B.B.
THIOREDOXINS IN THE RED ALGA *Porphyridium cruentum* (ABSTRACT).
*PLANT PHYSIOLOGY*
80(SUPPL.): 53, 1986. (GWU 7509)

JAHNKE*, L.L.
THE EFFECTS OF LOW OXYGEN ON THE SYNTHESIS OF UNSATURATED FATTY ACIDS AND
STEROLS: IMPLICATIONS FOR THE EVOLUTION OF EUKARYOTES.
*ORIGINS OF LIFE*
16(3-4): 317-318, 1986. (GWU 7510)

JAHNKE*, L.L.; NICHOLS, P.D.
METHYL STEROL AND CYCLOPROPADE FATTY ACID COMPOSITION OF *Methylococcus capsulatus*
GROWN AT LOW OXYGEN TENSIONS.
*JOURNAL OF BACTERIOLOGY*
JORGENSEN, B.B.; DES MARAIS*, D.J.
COMPETITION FOR SULFIDE AMONG COLORLESS AND PURPLE SULFUR BACTERIA IN CYANOBACTERIAL MATS.
FEMS MICROBIOLOGY ECOLOGY
38: 179-186, 1986. (GWU 7513)

JORGENSEN, B.B.; DES MARAIS*, D.J.
A SIMPLE FIBER-OPTIC MICROPROBE FOR HIGH RESOLUTION LIGHT MEASUREMENTS: APPLICATION IN MARINE SEDIMENT.
LIMNOLOGY AND OCEANOGRAPHY
31(6): 1376-1383, 1986. (GWU 7514)

JUKES*, T.H.;
THE GENETIC CODE--FROZEN ACCIDENT OR PREDETERMINED AS "BEST FIT" (ABSTRACT).
IN: ABSTRACTS, ANNUAL MEETING OF THE MOLECULAR BIOLOGY SOCIETY OF JAPAN, NAGOYA, JAPAN, DECEMBER 4-11, 1 P., 1986. (GWU 7517)

JUKES*, T.H.; BHUSHAN, V.
SILENT NUCLEOTIDE SUBSTITUTIONS AND G+C CONTENT OF SOME MITOCHONDRIAL AND BACTERIAL GENES.
JOURNAL OF MOLECULAR EVOLUTION
24: 39-44, 1986. (GWU 7518)

JUKES*, T.H.
The genetic codes, universal and non-universal.
IN: PAPERS, ANNUAL MEETING OF THE MOLECULAR BIOLOGY SOCIETY OF JAPAN, NAGOYA, JAPAN, DECEMBER 4-11, 4 P., 1986. (GWU 7519)

JUKES*, T.H.
VARIATIONS IN THE GENETIC CODE AND THEIR POSSIBLE EVOLUTIONARY SIGNIFICANCE (ABSTRACT).
ORIGINS OF LIFE
16(3-4): 477, 1986. (GWU 7520)

KAWAMURA, K.; TANNENBAUM, E.; HUIZINGA, B.J.; KAPLAN*, I.R.
LONG-CHAIN CARBOXYLIC ACIDS IN PYROLYSATES OF GREEN RIVER KEROGEN.
ORGANIC GEOCHEMISTRY
10: 1059-1065, 1986. (GWU 7524)

KAWAMURA, K.; TANNENBAUM, E.; HUIZINGA, B.J.; KAPLAN*, I.R.
VOLATILE ORGANIC ACIDS GENERATED FROM KEROGEN DURING LABORATORY HEATING.
GEOCHEMICAL JOURNAL
20: 51-59, 1986. (GWU 7525)
KNOLL*, A.H.; GRANT, S.W.F.; TSAO, J.W.
THE EARLY EVOLUTION OF LAND PLANTS.
IN: LAND PLANTS, NOTES FOR A SHORT COURSE (BROADHEAD, T.W., ED.).
KNOXVILLE, TN: UNIVERSITY OF TENNESSEE DEPARTMENT OF GEOLOGICAL SCIENCE,
P. 45-63, 1986. (GWU 7532)

KNOLL*, A.H.; GOLUBIC, S.; GREEN, J.; SWETT, K.
ORGANICALLY PRESERVED MICROBIAL ENDOLITHS FROM THE LATE PROTEROZOIC OF
EAST GREENLAND.
NATURE
321(6073): 856-857, 1986. (GWU 7533)

LAMBERT, I.B.
SECULAR VARIATION IN CARBON ISOTOPE RATIOS FROM UPPER PROTEROZOIC
SUCCESSIONS OF SVALBARD AND EAST GREENLAND.
NATURE
321(6073): 832-838, 1986. (GWU 7534)

KRISTJANSSON, H.; HOCHSTEIN*, L.I.
TRYPSIN DIGESTION FOR DETERMINING ORIENTATION OF ATPase IN Halobacterium
saccharovorum MEMBRANE VESICLES.
FEMS MICROBIOLOGY LETTERS
35: 171-175, 1986. (GWU 7535)

KRISTJANSSON, H.; HOCHSTEIN*, L.I.
HALOBACTERIAL ADENOSINE TRIPHOSPHATASES AND THE ADENOSINE
TRIPHOSPHATASE FROM Halobacterium saccharovorum.
FEMS MICROBIOLOGY LETTERS
35: 55-58, 1986. (GWU 7659)

LANYI*, J.K.; VODYANOY, V.
FLASH SPECTROSCOPIC STUDIES OF THE KINETICS OF THE HALORHODOPSIN
PHOTOCYCLE.
BIOCHEMISTRY

LEVINE*, J.S.
THE PRECAMBRIAN.
MCGRAW-HILL YEARBOOK OF SCIENCE AND TECHNOLOGY FOR 1987,
P. 387-389, 1986. (GWU 7542)

MANCINELLI, R.L.; CRONIN, S.; HOCHSTEIN*, L.I.
THE OCCURRENCE OF DENITRIFICATION IN EXTREMELY HALOPHILIC BACTERIA.
FEMS MICROBIOLOGY LETTERS
35: 55-58, 1986. (GWU 7549)
MANCINELLI, R.L.; HOCHSTEIN*, L.I.  
THE PURIFICATION AND PROPERTIES OF A cd-CYTOCHROME NITRITE REDUCTASE FROM Paracoccus halodenitrificans.  
ARCHIVES OF MICROBIOLOGY  

MARGULIS*, L.  
FROM ECOLOGY TO GEOGNOSY.  
THE ECOLOGIST  
16: 52-53, 1986. (GWU 7556)

MARGULIS*, L.  
EL ORIGEN DE LA CELULA (EARLY LIFE).  
BARCELONA, SPAIN: EDITORIAL REVERTE, S.A., 140 P. + xiv, 1986. (GWU 7559)

MARGULIS*, L.; BALUJA, L.; AWRAMIK, S.M.; SAGAN, D.  
COMMUNITY LIVING LONG BEFORE MAN: FOSSIL AND LIVING MICROBIAL MATS AND EARLY LIFE.  
THE SCIENCE OF THE TOTAL ENVIRONMENT  
56: 379-397, 1986. (GWU 7580)

MARGULIS*, L.; SAGAN, D.  
MICROCOSMOS: FOUR BILLION YEARS OF EVOLUTION FROM OUR MICROBIAL ANCESTORS.  
NEW YORK: SUMMIT BOOKS, 301 P., 1986. (GWU 7590)

MARGULIS*, L.; CHASE, D.; GUERRERO, R.  
MICROBIAL COMMUNITIES: INVISIBLE TO THE SCRUTINY OF NATURALISTS, MOST MICROBIAL COMMUNITIES HAVE ESCAPED DESCRIPTION.  
BIOSCIENCE  
36(3): 160-170, 1986. (GWU 7591)

MARGULIS*, L.; SAGAN, D.  
ORIGINS OF SEX: THREE BILLION YEARS OF GENETIC RECOMBINATION.  
NEW HAVEN, CT: YALE UNIVERSITY PRESS, 258 P. + xiii, 1986. (GWU 7592)

MARGULIS*, L.; SAGAN, D.  
STRANGE FRUIT ON THE TREE OF LIFE: HOW MAN-MADE OBJECTS MAY REMAKE MAN.  
THE SCIENCES  
26(3): 38-45, 1986. (GWU 7599)

MARTENS, C.S.; BLAIR, N.E.; GREEN, C.D.; DES MARAIS*, D.J.  
SEASONAL VARIATIONS IN THE STABLE CARBON ISOTOPIC SIGNATURE OF BIOGENIC METHANE IN A COASTAL SEDIMENT.  
SCIENCE  
233(4770): 1300-1303, 1986. (GWU 7660)
MATHEWS, W.R.; BIEMANN*, K.
MASS SPECTROMETRIC COMPARISON OF THE AMINO ACID SEQUENCES OF
THIOREDOXINS FROM VARIOUS SOURCES.
IN: THIOREDOXIN AND GLUTAREDOXIN SYSTEMS: STRUCTURE AND FUNCTION
(HOLMGREN, A., BRANDEN, C.-I., JORNVALL, H., SJOBERG, B.-M. EDS.).
NEW YORK: RAVEN PRESS, P. 47-56, 1986. (GWU 7554)

MCGL, T.J.; JURKA, J.; SOBIESKI, J.M.; PICKETT, M.H.;
WOESE*, C.R.; FOX*, G.E.
CHARACTERISTIC ARCHAEBACTERIAL 16S rRNA OLIGONUCLEOTIDES.
SYSTEMATIC AND APPLIED MICROBIOLOGY
7: 194-197, 1986. (GWU 7600)

SCHOBERT, B.; LANYI*, J.K.
ELECTROSTATIC INTERACTION BETWEEN ANIONS BOUND TO SITE I AND THE RETINAL
SCHIFF BASE OF HALORHODOPSIN.
BIOCHEMISTRY
25(14): 4163-4167, 1986. (GWU 7602)

SCHOPF*, J.W.; PACKER, B.M.
NEWLY DISCOVERED EARLY ARCHEAN (3.4.-3.5 Ga OLD) MICROORGANISMS FROM
THE WARRAWOONA GROUP OF WESTERN AUSTRALIA (ABSTRACT).
ORIGINS OF LIFE
16(3-4): 163-164, 1986. (GWU 7661)

SOMMER, M.A.; GIBSON*, E.K., JR.
VOLATILE DETERMINATIONS OF INDIVIDUAL FLUID INCLUSIONS WITHIN THE 3.4 b.y.
NORTH POLE BARITES FROM THE WARRAWOONA GROUP, NORTHWESTERN AUSTRALIA.
LUNAR AND PLANETARY SCIENCE
XVII: 815-816, 1986. (GWU 7662)

TANNENBAUM, E.; RUTH, E.; HUIZINGA, B.J.; KAPLAN*, I.R.
BIOLOGICAL MARKER DISTRIBUTION IN COEXISTING KEROGEN, BITUMEN AND
ASPHaltenES IN MONTEREY FORMATION DIATOMITE, CALIFORNIA.
ORGANIC GEOCHEMISTRY
10: 531-536, 1986. (GWU 7607)

TANNENBAUM, E.; HUIZINGA, B.J.; KAPLAN*, I.R.
ROLE OF MINERALS IN THERMAL ALTERATION OF ORGANIC MATTER - II: A MATERIAL
BALANCE.
AMERICAN ASSOCIATION OF PETROLEUM GEOLoGISTS BULLETIN
70(9): 1156-1165, 1986. (GWU 7613)
TANNENBAUM, E.; RUTH, E.; KAPLAN*, I.R.
STERANES AND TRITERPANES GENERATED FROM KEROGEN PYROLYSIS IN THE
ABSENCE AND PRESENCE OF MINERALS.
GEOCHIMICA ET COSMOCHIMICA ACTA
50: 805-812, 1986. (GWU 7614)

Halobacterium dentrificans sp. nov., AN EXTREMELY HALOPHILIC DENITRIFYING
BACTERIUM.
INTERNATIONAL JOURNAL OF SYSTEMATIC BACTERIOLOGY

VOSSBRINCK, C.R.; WOESE*, C.R.
EUkARYOTIC RIBOSOMES THAT LACK A 5.8S RNA.
NATURE

WALKER*, J.C.G.; ZAHNLE, K.J.
LUNAR NODAL TIDE AND DISTANCE TO THE MOON DURING THE PRECAMBRIAN.
NATURE
320: 600-602, 1986. (GWU 7619)

WOESE*, C.R.; OLSEN, G.J.
ARCHAEBACTERIAL PHYLOGENY: PERSPECTIVES ON THE URKINGDOMS.
SYSTEMATIC AND APPLIED MICROBIOLOGY
7: 161-177, 1986. (GWU 7620)
KASTING*, J.F.; ACKERMAN, T.P.
CLIMATIC CONSEQUENCES OF VERY HIGH CARBON DIOXIDE LEVELS IN THE
EARTH'S EARLY ATMOSPHERE.
SCIENCE
234(4782): 1383-1385, 1986. (GWU 6838)

KASTING*, J.F.; RICHARDSON, S.M.; POLLACK, J.B.; TOON, O.B.
A HYBRID MODEL OF THE CO2 GEOCHEMICAL CYCLE AND ITS APPLICATION
TO LARGE IMPACT EVENTS.
AMERICAN JOURNAL OF SCIENCE
286: 361-389, 1986. (GWU 7523)

MCKAY*, C.P.; LONG, A.; FRIEDMANN*, E.I.
RADIOCARBON DATING OF OPEN SYSTEMS WITH BOMB EFFECT.
JOURNAL OF GEOPHYSICAL RESEARCH
91(B3): 3836-3840, 1986. (GWU 7558)

MCSHEA, D.W.; RAUP*, D.M.
COMPLETENESS OF THE GEOLOGICAL RECORD.
JOURNAL OF GEOLOGY
94: 569-574, 1986. (GWU 7570)

RAUP*, D.M.
MAJOR FEATURES OF THE FOSSIL RECORD AND THEIR IMPLICATIONS FOR
EVOLUTIONARY RATE STUDIES.
IN: RATES OF EVOLUTION (CAMPBELL, K.S.W., DAY, M.F., EDS.).
LONDON: ALLEN AND UNWIN, P. 1-14, 1986. (GWU 7571)

RAUP*, D.M.
BIOLOGICAL EXTINCTION IN EARTH HISTORY.
SCIENCE
231: 1528-1533, 1986. (GWU 7572)

RAUP*, D.M.; SEPKOSKI*, J.J., JR.
PERIODIC EXTINCTION OF FAMILIES AND GENERA.
SCIENCE
231: 833-836, 1986. (GWU 7582)

SEPKOSKI*, J.J., JR.; RAUP*, D.M.
WAS THERE 26-MYR PERIODICITY OF EXTINCTIONS?
NATURE
321: 533, 1986. (GWU 7615)
SEPkoski, J.J., Jr.; Raup, D.M.
PERIODICITY IN MARINE EXTINCTION EVENTS.
IN: DYNAMICS OF EXTINCTION (Elliott, D.K., Ed.).
NEW YORK: JOHN WILEY AND SONS, P. 3-36, 1986. (GWU 7581)
SOLAR SYSTEM EXPLORATION
LABORATORY INVESTIGATIONS OF MARS: CHEMICAL AND SPECTROSCOPIC CHARACTERISTICS OF A SUITE OF MARS SOIL ANALOGS.
ORIGINS OF LIFE
16: 403-404, 1986. (GWU 7626)

GAS CHROMATOGRAPHIC INSTRUMENTATION FOR THE ANALYSIS OF AEROSOLS AND GASES IN TITAN'S ATMOSPHERE.
LUNAR AND PLANETARY SCIENCE
XVII: 103-104, 1986. (GWU 7211)

AMINO ACIDS DERIVED FROM TITAN THOLINS.
ICARUS
68(1): 176-185, 1986. (GWU 7528)

THE URANIAN STRATOSPHERE: HYDROCARBON GASES AND SOLIDS FROM CORONAL DISCHARGE (ABSTRACT).
BULLETIN OF THE AMERICAN ASTROPHYSICAL SOCIETY
18(3): 765, 1986. (GWU 7529)

MATHOG, J.Y.; MCKAY*, C.P.; MANCINELLI, R.L.
INTERACTION OF THOLIN MATERIAL AND A LIQUID ETHANE OCEAN ON TITAN.
ORIGINS OF LIFE
16(3-4): 416-418, 1986. (GWU 7555)

MCKAY*, C.P.
COMMENT ON "ON THE FLUX OF SMALL COMETS INTO THE EARTH'S UPPER ATMOSPHERE. II. INTERPRETATION".
GEOPHYSICAL RESEARCH LETTERS
13: 976-978, 1986. (GWU 7623)

MCKAY*, C.P.; POLLACK, J.B.
 RADIOACTIVE-CONNECTIVE MODEL OF TITAN'S ATMOSPHERE.
BULLETIN OF THE AMERICAN ASTROPHYSICAL SOCIETY
17: 739-740, 1986. (GWU 7624)

MCKAY*, C.P.; MANCINELLI, R.L.; CARLE*, G.C.
EXOBIOLOGY AND FUTURE MARS MISSION.
ORIGINS OF LIFE
16: 416-417, 1986. (GWU 7625)
MCKAY*, C.P.; SQUYRES, S.W.; REYNOLDS, R.T.
METHODS FOR COMPUTING COMET CORE TEMPERATURES.
ICARUS
66: 625-629, 1986. (GWU 7557)

PAPPALARDO, R.L.; THOMPSON, W.R.; SAGAN*, C.
PHOTOCLINOMETRY ON IO: TOPOGRAPHY FROM MINNAERT INVERSION (ABSTRACT).
BULLETIN OF THE AMERICAN ASTRONOMICAL SOCIETY
18(3): 777, 1986. (GWU 7646)

THERMAL DESORPTION MODULATION AS A REPLACEMENT FOR SAMPLE INJECTION IN
VERY-SMALL-DIAMETER GAS CHROMATOGRAPHY CAPILLARY COLUMNS.
JOURNAL OF CHROMATOGRAPHIC SCIENCES
24: 396-399, 1986. (GWU 7567)

PINTO, J.P.; LUNINE, J.J.; KIM, S.-J.; YUNG*, Y.L.
D TO H RATIO AND THE ORIGIN AND EVOLUTION OF TITAN'S ATMOSPHERE.
NATURE

POLLOCK*, G.E.
SYNTHESIS OF A FURTHER IMPROVED POROUS POLYMER FOR THE SEPARATION OF
NITROGEN, OXYGEN, ARGON, AND CARBON MONOXIDE BY GAS CHROMATOGRAPHY.
JOURNAL OF CHROMATOGRAPHIC SCIENCE

SAGAN*, C.; THOMPSON, W.R.; KHARE*, B.N.; MURRAY, B.G.J.P.T.
RADIATION DARKENING OF CH4-CLATHRATE: IMPLICATIONS FOR THE URANIAN
SATELLITES.
BULLETIN OF THE AMERICAN ASTRONOMICAL SOCIETY
18(3): 785, 1986. (GWU 7574)

SCATTERGOOD*, T.; MCKAY*, C.P.; BORUCKI, W.; KASTING*, J.;
OHARA*, B.; MILLER*, S.
ABIOTIC SYNTHESIS OF ORGANIC GASES AND AEROSOLS IN THE ATMOSPHERE OF TITAN.
ORIGINS OF LIFE
16(3-4): 238-239, 1986. (GWU 7576)

SCATTERGOOD*, T.W.; MCKAY*, C.P.
ARE ALL TITAN THOLINS ALIKE? COMPARISON OF SPECTRA OF MATERIALS MADE BY
ELECTRIC DISCHARGE, LASER-SUPPORTED SHOCK, AND PROTON IRRADIATION.
BULLETIN OF THE AMERICAN ASTRONOMICAL SOCIETY
18(3): 816, 1986. (GWU 7577)
TARTER*, J.C.; BLACK, D.C.; BILLINGHAM*, J.
REVIEW OF METHODOLOGY AND TECHNOLOGY AVAILABLE FOR THE DETECTION OF EXTRASOLAR PLANETARY SYSTEMS.
JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY
39: 418-424, 1986. (GWU 7595)

THOMPSON, W.R.; HENRY, T.; KHARE*, B.N.; SAGAN*, C.
CHARGED PARTICLE ORGANIC SYNTHESIS IN LOW AND MODERATE PRESSURE N₂-CH₄ ATMOSPHERES: IMPLICATIONS FOR TITAN AND TRITON (ABSTRACT).
BULLETIN OF THE AMERICAN ASTRONOMICAL SOCIETY
18(3): 816-817, 1986. (GWU 7598)

WHARTON*, R.A., JR.
UNDER THE ICE IN ANTARCTICA.
EXPLORERS JOURNAL
64: 62-65, 1986. (GWU 7605)

WHARTON*, R.A., JR.; MCKAY*, C.P.; SIMMONS, G.M., JR.; PARKER, B.C.
OXYGEN BUDGET OF A PERENNIALY ICE-COVERED ANTARCTIC LAKE.
LIMNOLOGY AND OCEANOGRAPHY
31(2): 437-443, 1986. (GWU 7606)
SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)
BETZ*, A.
A DIRECTED SEARCH FOR EXTRATERRESTRIAL LASER SIGNALS.
ACTA ASTRONAUTICA

BETZ*, A.
INFRARED OBSERVATIONS OF CIRCUMSTELLAR MOLECULES.
IN: ASTROCHEMISTRY (VARDYA, M.S., TARAFCAR, S.P., EDS.).

BILLINGHAM*, J.
RISK AND VALUE ANALYSIS OF SETI.
IN: PAPERS, 37TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION,
INNSBRUCK, AUSTRIA, OCTOBER 4-11, 6 P., 1986. (IAF PAPER 86-469)
(GWU 8186)

CULLERS*, D.K.
SENSITIVE DETECTION OF NARROWBAND PULSES.
ACTA ASTRONAUTICA
13(1): 31-37, 1986. (GWU 7216)

CULLERS*, D.K.; DEANS, S.R.
NARROWBAND SIGNAL DETECTION IN THE SETI FIELD TEST.
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7217)

DIXON*, R.S.
MACRO EVENTS IN A SETI ARCHIVE.
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7225)

DOMINGUE, D.; RANKIN, J.M.; WEISBERG, J.M.; BACKUS*, P.R.
PULSAR PSR 0656+14: PERIOD AND SPINDOWN.
ASTRONOMY AND ASTROPHYSICS
161: 303-304, 1986. (GWU 7226)

TWICKEN, J.
VLSI PROCESSORS FOR SIGNAL DETECTION IN SETI.
IN: PAPERS, 37TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION,
INNSBRUCK, AUSTRIA, OCTOBER 4-11, 7 P., 1986. (IAF PAPER 86-489)
(GWU 8185)
GULKIS*, S.
ANALYSIS OF A CROSSED BRAGG-CELL ACOUSTO OPTICAL SPECTROMETER FOR SETI.
IN: PAPERS, 37TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION,
INNSBRUCK, AUSTRIA, OCTOBER 4-11, 14 P., 1986. (IAF PAPER 86-488)
(GWU 7500)

GULKIS*, S.; OLSEN, E.T.
The NASA SETI Program at JPL
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7501)

DOWNS, G.S.; QUIRK, M.P.; LOKSHIN, A.; SOLOMON, J.
OBJECTIVES AND FIRST RESULTS OF THE NASA SETI SKY SURVEY FIELD TESTS AT
GOLDSTONE.
IN: TDA PROGRESS REPORT 42-86.
PASADENA, CA: CALIFORNIA INSTITUTE OF TECHNOLOGY, JET PROPULSION
LABORATORY, P. 284-293, APRIL-JUNE, 1986. (GWU 7502)

HOROWITZ, P.; MATHEWS, B.S.; FORSTER, J.; LINSKOTT*, I.;
TEAGUE, C.C.; CHEN, K.; BACKUS*, P.
ULTRANARROWBAND SEARCHES FOR EXTRATERRESTRIAL INTELLIGENCE WITH
DEDICATED SIGNAL-PROCESSING HARDWARE.
ICARUS
67: 525-539, 1986. (GWU 7506)

KLEIN*, M.J.
RADIO ASTRONOMY ASPECTS OF THE NASA SETI SKY SURVEY.
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7531)

LINSKOTT*, I.
ARE 100 MILLION CHANNELS ENOUGH?
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7543)

OLIVER*, B.M.
THE NASA SETI PROGRAM: AN OVERVIEW.
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,
SEIELSTAD, G.A., EDS.).
(GWU 7564)
SATORIUS, E.H.; GRIMM, M.J.; ZIMMERMAN, G.A.; WILCK, H.C.  
(KLEIN, M.J. = P.I.)  
FINITE WORDLENGTH IMPLEMENTATION OF A MEGACHANNEL DIGITAL SPECTRUM  
ANALYZER.  
IN: TDA PROGRESS REPORT 42-86.  
PASADENA, CA: CALIFORNIA INSTITUTE OF TECHNOLOGY, JET PROPULSION  
LABORATORY, P. 244-254, APRIL-JUNE, 1986. (GWU 7575)

TARTER*, J.C.; WELCH, W.J.  
A CLOUD COLLISION MODEL FOR WATER MASER EXCITATION.  
ASTrophysical journal  
305(1): 467-483, 1986. (GWU 7593)

TARTER*, J.C.  
AN HISTORICAL PERSPECTIVE: BROWN IS NOT A COLOR.  
IN: ASTrophysics Of Brown DwarfS (kafatos, M.C., Harrington, R.S.,  
Maran, S.P., Eds.).  
7594)

TARTER*, J.  
NOTes AND NeWs: CESRA Workshop On Radio Continua During Solar Flares  
BULLETIN OF THE ASTRONOMICAL SOCIETY OF INDIA  
14: 56-63, 1986. (GWU 7596)

TARTER*, J.C.  
SETI OBSERVATIONS WORLDWIDE.  
IN: THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (KELLERMANN, K.I.,  
Seielstad, G.A., Eds.).  
(GWU 7597)

TARTER*, J.  
RADIO FREQUENCY INTERFERENCE AT JODRELL Bank OBSERVATORY WITHIN THE  
PROJECTED 21 CM BAND.  
IN: PAPERS, 37TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION,  
Innsbruck, Austria, October 4-11, 12 P., 1986. (IAF PAPER 86-485).  
(GWU 8184)

WERTHIMER, D.; BRADY, R.; BEREZIN, A.; BOWYER*, S.  
A SEARCH FOR NARROW BAND SIGNALS WITH SERENDIP II: A PROGRESS REPORT.  
IN: PAPERS, 37TH INTERNATIONAL ASTRONAUTICAL FEDERATION CONGRESS,  
Innsbruck, Austria, October 4-11, 10 P., 1986. (IAF PAPER 86-484)  
(GWU 7604)
THESE PUBLICATIONS WERE INADVERTENTLY OMITTED FROM THE 1985 BIBLIOGRAPHY.

BILLINGHAM*, J.
THE EVOLUTION OF COMPLEX LIFE.
(GWU 8181)

DIXON*, R.S.
THE OHIO SETI PROGRAM - THE FIRST DECADE.
IN: THE SEARCH FOR EXTRATERRESTRIAL LIFE: RECENT DEVELOPMENTS (PAPAGIANNIS, M.D., ED.).
(GWU 8189)

IRVINE*, W.M.
SUMMARY OF SESSION II: PLANETARY, INTERPLANETARY AND INTERSTELLAR ORGANIC MATTER.
IN: THE SEARCH FOR EXTRATERRESTRIAL LIFE: RECENT DEVELOPMENTS (PAPAGIANNIS, M.D., ED.).
(GWU 8190)

KLEIN*, H.P.
IN SITU SEARCH FOR EXTRATERRESTRIAL LIFE.
(GWU 8183)

ORGEL*, L.
MOLECULAR REPLICATION
IN: THE SEARCH FOR EXTRATERRESTRIAL LIFE: RECENT DEVELOPMENTS (PAPAGIANNIS, M.D., ED.).
(GWU 8191)

OWEN*, T.
LIFE AS A PLANETARY PHENOMENON.
ORIGINS OF LIFE
SHOSTAK, G.S.; TARTER*, J.
"SIGNAL" SEARCH FOR INTELLIGENCE IN THE GALACTIC NUCLEUS WITH THE ARRAY
OF THE LOWLANDS.
ACTA ASTRONAUTICA

TARTER*, J.C.
STATISTICS OF 'EXCESS' OBSERVATORY NOISE AT THE NANCAY TELESCOPE
AND ELSEWHERE.
IN: PAPERS, 36TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL
Federation, Stockholm, Sweden, October 7-12, 9 p., 1985. (IAF PAPER
85-473)
(GWU 8182)
APPENDIX
APPENDIX

DR. LUIS ALVAREZ
Lawrence Berkeley Laboratories
University of California
Berkeley, CA 94720

DR. GUSTAF ARRHENIUS
Scripps Institution of Oceanography
Mail Code A-020
University of California, San Diego
La Jolla, CA 92093

DR. AMOS BANIN
NASA, Ames Research Center
Moffett Field, CA 94035

DR. ALBERT BETZ
Space Sciences Laboratory
University of California
Berkeley, CA 94720

DR. KLAUS BIEMANN
Department of Chemistry
Massachusetts Institute of Technology
Cambridge, MA 02139

DR. JOHN BILLINGHAM
NASA, Ames Research Center
Life Science Division
Mail Stop 239-11
Moffett Field, CA 94035

DR. STUART BOWYER
Space Sciences Laboratory
University of California
Berkeley, CA 94720

DR. BOB B. BUCHANAN
Division of Molecular Plant Biology
Hilgard Hall
University of California
Berkeley, CA 94720

DR. THEODORE E. BUNCH
NASA, Ames Research Center
Mail Stop 239-12
Code LX
Moffett Field, CA 94035

DR. GLENN C. CARLE
NASA, Ames Research Center
Mail Stop 239-12
Code LX
Moffett Field, CA 94035
APPENDIX

DR. SHERWOOD CHANG  
NASA, Ames Research Center  
Mail Stop 239-12  
Code LX  
Moffett Field, CA  94035

DR. JOHN B. CORLISS  
Department of Chemistry  
Georgetown University  
Washington, D.C.  20057

DR. LELIA COYNE  
Department of Chemistry  
San Jose State University  
San Jose, CA  95192

DR. JOHN R. CRONIN  
Department of Chemistry  
Arizona State University  
Tempe, AZ  85287

DR. R.B. CROW  
California Institute of Technology  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA  91109

DR. D.K. CULLERS  
California Institute of Technology  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA  91109

DR. DOUG J. DEFFREES  
Molecular Research Institute  
701 Welch Road, Suite 203  
Palo Alto, CA  94304

DR. DAVID J. DES MARAIS  
NASA, Ames Research Center  
Planetary Biology Branch  
Mail Stop 239-12  
Code LX  
Moffett Field, CA  94035

DR. L.J. DEUTSCH  
California Institute of Technology  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA  91109
APPENDIX

DR. ROBERT S. DIXON
Ohio State University Radio Observatory
2015 Neil Avenue
Columbus, OH 43210

DR. FREDERICK R. EIRICH
Department of Chemistry
Polytechnic Institute of New York
Brooklyn, NY 11201

DR. ROBERT C. FAHEY
Department of Chemistry, D-006
University of California, San Diego
La Jolla, CA 92093

DR. JAMES P. FERRIS
Department of Chemistry
School of Science
Rensselaer Polytechnic Institute
Troy, NY 12180

DR. CLAIR E. FOLSOME
Laboratory of Exobiology
Department of Microbiology
University of Hawaii, Manoa
Honolulu, HI 98622

DR. GEORGE E. FOX
Department of Biochemical and Biophysical Sciences
University of Houston
4800 Calhoun Road
Houston, TX 77004

DR. SIDNEY W. FOX
Institute for Molecular and Cellular Evolution
University of Miami
521 Anastasia
Coral Gables, FL 33134

DR. E. IMRE FRIEDMANN
Department of Biological Science
Florida State University
Tallahassee, FL 32306

DR. EVERETT K. GIBSON, JR.
NASA, Johnson Space Center
SN4/Experimental Planetology Branch
Solar System Exploration Division
Space and Life Sciences Directorate
Houston, TX 77058
APPENDIX

DR. SAMUEL GULKIS
California Institute of Technology
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA  91109

DR. HYMAN HARTMAN
Francis Bitter National Magnet Laboratory
Massachusetts Institute of Technology
Cambridge, MA  02139

DR. JOHN M. HAYES
Biogeochemical Laboratories
Geology Building
Indiana University
Bloomington, IN  47405

DR. LAWRENCE I. HOCHSTEIN
NASA, Ames Research Center
Mail Stop 239-10
Code LX
Moffett Field, CA  94035

DR. HEINRICH D. HOLLAND
Department of Geological Sciences
Hoffman Laboratory
20 Oxford Street
Harvard University
Cambridge, MA  02138

DR. WILLIAM IRVINE
Five College Radio Astronomy Observatory
619 Lederle Graduate Research Center
University of Massachusetts
Amherst, MA  01003

MS. LINDA L. JAHNKE
NASA, Ames Research Center
Mail Stop 239-10
Code SLX
Moffett Field, CA  94035

DR. THOMAS JUKES
Space Science Laboratory
University of California
6701 San Pablo Avenue
Oakland, CA  94608
APPENDIX

DR. ISAAC R. KAPLAN
Institute of Geophysics and Planetary Physics
University of California
Los Angeles, CA 90024

DR. JAMES F. KASTING
NASA, Ames Research Center
Theoretical Studies Branch
Mail Stop 245-3
Code SST
Moffett Field, CA 94035

DR. JOHN F. KERRIDGE
Institute of Geophysics and Planetary Physics
University of California
Los Angeles, CA 90024

DR. BISHUN N. KHARE
Laboratory for Planetary Studies
Center for Radiophysics and Space Research
Cornell University
Ithaca, NY 14853

DR. MICHAEL J. KLEIN
California Institute of Technology
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

DR. ANDREW H. KNOLL
Botanical Museum of Harvard University
26 Oxford Street
Cambridge, MA 02138

DR. DANIEL R. KOJIRO
NASA, Ames Research Center
Mail Stop 239-12
Code LXE
Moffett Field, CA 94035

DR. JAMES C. LACEY, JR.
Department of Biochemistry
Room 520 CHSB
University Station
University of Alabama
Birmingham, AL 35294
APPENDIX

DR. JANOS K. LANYI
Department of Physiology
and Biophysics
California College of Medicine
University of California
Irvine, CA 92717

DR. JOEL S. LEVINE
NASA, Langley Research Center
Atmospheric Sciences Division
Hampton, VA 23665

DR. IVAN LINSWIT
NASA, Ames Research Center
Code LX
Moffett Field, CA 94035

DR. ROBERT D. MACELROY
NASA, Ames Research Center
Mail Stop 239-4
Code LX
Moffett Field, CA 94035

DR. LYNN MARGULIS
Biological Science Center
2 Cummingston Street
Boston University
Boston, MA 02215

DR. DAVID MAUZERALL
Department of Biophysics
Rockefeller University
1230 York Avenue
New York, NY 10021

DR. CHRISTOPHER MCKAY
NASA, Ames Research Center
Mail Stop 239-12
Code LXE
Moffett Field, CA 94035

DR. STANLEY L. MILLER
Department of Chemistry, B-017
University of California, San Diego
La Jolla, CA 92039

DR. BONNIE O'HARA
Mail Stop 239-12
NASA, Ames Research Center
Moffett Field, CA 94035

DR. BERNARD M. OLIVER
NASA, Ames Research Center
Mail Stop 229-8
Moffett Field, CA 94035
APPENDIX

DR. JAMES B. ORENBERG  
Department of Chemistry  
and Biochemistry  
San Francisco State University  
1600 Holloway Avenue  
San Francisco, CA 94132

DR. LESLIE E. ORGEL  
The Salk Institute for Biological Studies  
P.O. Box 85800  
San Diego, CA 92138

DR. JOHN OR0  
Department of Biochemical  
and Biophysical Sciences  
Laboratory of Biomolecular Analysis  
University of Houston  
Houston, TX 77004

DR. TOBIAS OWEN  
Department of Earth and Space Sciences  
State University of New York  
Stony Brook, NY 11794

DR. MICHAEL D. PAPAGIANNIS  
Department of Astronomy  
Boston University  
Boston, MA 02215

MR. GLENN E. POLLOCK  
NASA, Ames Research Center  
Solar System Exploration Office  
Mail Stop 239-12  
Code LXE  
Moffett Field, CA 94035

DR. CYRIL PONNAMPERUMA  
Laboratory of Chemical Evolution  
Department of Chemistry  
University of Maryland  
College Park, MD 20742

DR. DAVID M. RAUP  
Department of Geophysical Sciences  
University of Chicago  
5734 South Ellis Avenue  
Chicago, IL 60637

DR. ROBERT REIN  
Roswell Park Memorial Institute  
New York State Department of Health  
666 Elm Street  
Buffalo, NY 14263
APPENDIX

DR. ALEXANDER RICH
Department of Biology
Massachusetts Institute of Technology
Cambridge, MA 02139

DR. JOHN D. RUMMEL
Program Manager, Exobiology
Code EBR
National Aeronautics and Space Administration
600 Independence Avenue, S.W.
Washington, D.C. 20546

DR. CARL E. SAGAN
Center for Radiophysics and Space Research
Laboratory for Planetary Studies
Space Sciences Building
Cornell University
Ithaca, NY 14853

DR. THOMAS SCATTERGOOD
NASA, Ames Research Center
Mail Stop 239-12
Code LX
Moffett Field, CA 94035

DR. J. WILLIAM SCHOPF
Department of Earth and Space Sciences
3806 Geology Building
University of California
Los Angeles, CA 90024

DR. J. JOHN SEPKOSKI
Department of Geophysical Sciences
University of Chicago
5734 South Ellis Avenue
Chicago, IL 60637

DR. JILL TARTER
NASA, Ames Research Center
Mail Stop 229-8
Code SSL
Moffett Field, CA 94035

DR. DAVID A. Usher
Department of Chemistry
Baker Laboratory
Cornell University
Ithaca, NY 14853
APPENDIX

DR. JOSE R. VALENTIN
NASA, Ames Research Center
Mail Stop 239-12
Code LX
Moffett Field, CA 94035

DR. JAMES C.G. WALKER
Department of Atmospheric and Oceanic Science
Space Physics Research Laboratory
Space Research Building
University of Michigan
Ann Arbor, MI 48109

DR. ARTHUR L. WEBER
The Salk Institute for Biological Studies
P.O. Box 85800
San Diego, CA 92138

DR. ROBERT A. WHARTON, JR.
Desert Research Institute
Atmospheric Science Center
P.O. Box 60220
University of Nevada
Reno, NV 89506

DR. DAVID H. WHITE
Department of Chemistry
Santa Clara University
Santa Clara, CA 95053

DR. FRITZ H. WOELLER
Mail Stop 239-12
NASA-Ames Research Center
Moffett Field, CA 94035

DR. CARL R. WOESE
Department of Microbiology
131 Burrill Hall
University of Illinois
407 South Goodwin Avenue
Urbana, IL 61801

DR. GEORGE U. YUEN
Department of Chemistry
Arizona State University
Tempe, AZ 85287

DR. YUK LING YUNG
Division of Geology and Planetary Studies, 170-25
California Institute of Technology
Pasadena, CA 91125

62
### Report Documentation Page

1. **Report No.**
   - NASA TM-4029

2. **Government Accession No.**
   - 78

3. **Recipient's Catalog No.**
   - A04

4. **Title and Subtitle**
   - Publications of the Exobiology Program for 1986 — A Special Bibliography

5. **Report Date**
   - March 1988

6. **Performing Organization Code**
   - EBR

7. **Author(s)**
   - For previous bibliography in this series, see NASA TM-89605

8. **Performing Organization Report No.**
   - NASW-3165

9. **Performing Organization Name and Address**
   - Science Communication Studies, DCE
   - The George Washington University
   - Washington, DC 20036
   - NASA Office of Space Science and Applications

10. **Sponsoring Organization Name and Address**
    - National Aeronautics and Space Administration
    - Washington, DC 20546

11. **Contract or Grant No.**
    - NASW-3165

12. **Type of Report and Period Covered**
    - Technical Memorandum

13. **Sponsoring Agency Code**
    - For Sale by the National Technical Information Service, Springfield, VA 22161-2171

14. **Sponsoring Agency Code**
    - NASA-Langley, 1988

15. **Supplementary Notes**
    - List of 1986 publications resulting from research pursued under the auspices of NASA's Exobiology Program.

16. **Abstract**
    - For previous bibliography in this series, see NASA TM-89605

17. **Key Words (Suggested by Author(s))**
    - chemical evolution, prebiotic evolution, evolution of life, origin of life, exobiology, extraterrestrial life, SETI, bibliography, solar system exploration

18. **Distribution Statement**
    - Unclassified - Unlimited

19. **Security Classif. (of this report)**
    - Unclassified

20. **Security Classif. (of this page)**
    - Unclassified

21. **No. of pages**
    - 68

22. **Price**
    - A04