

II. RESEARCH PLAN - BOOK II

This is an application for renewal of a grant supporting the Stanford University Medical EXperimental computer (SUMEX) research resource for applications of Artificial Intelligence in Medicine (AIM). The research plan has been divided into several logical parts:

- 1) Book I - Resource research objectives and rationale, progress report, and detailed research plans.
- 2) Book II - Biographical sketches, collaborating project reports and plans, and supporting appendixes.
- 3) Budget - First year budget detail, five-year budget summary, and budget explanation and justification.

5 BIOGRAPHICAL SKETCHES

The following are biographical sketches for all professional personnel contributing to the SUMEX-AIM resource project. These do not include sketches for individual collaborating project investigators.

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME FEIGENBAUM, Edward A.	TITLE Professor and Chairman Computer Science Department	BIRTHDATE (Mo., Day, Yr.) January 20, 1936
PLACE OF BIRTH (City, State, Country) Weehawken, New Jersey, U.S.A.	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date) U.S. citizen	SEX <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Carnegie Institute of Technology, Pittsburgh, Pennsylvania	B.S.	1956	Electrical Engineering
Carnegie Institute of Technology, Pittsburgh, Pennsylvania	Ph.D.	1959	Industrial Administration

## HONORS

MAJOR RESEARCH INTEREST Artificial Intelligence	ROLE IN PROPOSED PROJECT Co-Investigator
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## RESEARCH SUPPORT (See instructions)

(See continuation page.)

## RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

1976 - present Professor (by Courtesy) Department of Psychology, Stanford University  
 1976 - present Chairman, Department of Computer Science, Stanford University  
 1969 - present Professor of Computer Science, Stanford University  
 1965 - 1968 Associate Professor of Computer Science, Stanford University  
 1965 - 1968 Director, Stanford Computation Center, Stanford University  
 1964 - 1965 Associate Professor, School of Business Administration,  
 University of California, Berkeley  
 1960 - 1963 Assistant Professor, School of Business Administration,  
 University of California, Berkeley  
 1961 - 1964 Research Appointment, Center for Human Learning,  
 University of California, Berkeley  
 1960 - 1964 Research Appointment, Center for Research in Management Science,  
 University of California, Berkeley  
 1965 - present Editor, Computer Science Series, McGraw-Hill Book Company, New York  
 1968 - 1972 Member, Computer and Biomathematical Sciences Study Section, NIH

Professional Societies: American Psychological Association, American Association for the Advancement of Science, Association for Computing Machinery (member, National Council of ACM, 1966-68)

Consultantships: Information Sciences Institute, University of Southern California; The RAND Corporation; System Development Corporation (knowledge-based systems project); Systems Control, Inc. (HASP project)

PUBLICATIONS (See continuation page.)

## BIOGRAPHICAL SKETCH - FEIGENBAUM, Edward A.

## RESEARCH SUPPORT

1. Contract No.: DAHC-15-73-C-0435  
 Title of Project: Heuristic Programming Project  
 Grant Agency: ARPA
  - a. Project Period: 7/73 - 7/77  
 Annual Funding: \$ 225,762  
 % of Effort: 90% summer, 40% academic year
  - b. Proposed Renewal: 8/77 - 9/79  
 Annual Funding: \$ 375,000 (8/77-9/78), \$ 350,000 (10/78-9/79)  
 % of Effort: 33% summer 1977, 17% academic year 1977-78,  
 100% summer 1978, 18% academic year 1978-79
  
2. Grant No.: RR-00612  
 Title of Project: Resource Related Research -  
 Computers and Chemistry (DENDRAL)  
 Project Period: 5/77 - 4/80  
 Annual Funding: \$ 218,580 (5/77-4/78) (Direct Costs)  
 % of Effort: 5% (no salary)  
 Grant Agency: NIH
  
3. Grant No.: MCS 74-23461  
 Title of Project: Automation of Scientific Inference:  
 Heuristic Computing Applied to  
 Protein Crystallography  
 Project Period: 2/75 - 4/79 + 6 mos.  
 Annual Funding: \$ 75,000  
 % of Effort: 5% (no salary)  
 Grant Agency: NSF
  
4. Grant No.: MCS 76-11649  
 Title of Project: MOLGEN: A Computer Science Application  
 to Molecular Genetics  
 Project Period: 6/76 - 5/78 + 6 mos.  
 Annual Funding: \$ 55,350  
 % of Effort: 10% academic year, 100% summer (2 mos. 1977)  
 Grant Agency: NSF

## Proposal Submitted:

Title of Project: Biomedical Knowledge Engineering  
 in Clinical Medicine  
 Project Period: 1/78 - 12/80  
 Annual Funding: \$ 170,879 (Direct Costs)  
 % of Effort: 10% (no salary)  
 Grant Agency: NIH (subcontract)

BIOGRAPHICAL SKETCH - FEIGENBAUM, Edward A.

PUBLICATIONS

Books and Monographs:

Computers and Thought, co-editor with Julian Feldman, McGraw-Hill, 1963.

Information Processing Language V Manual, Englewood Cliffs, N.J., Prentice-Hall, 1961 (with A. Newell, F. Tonge, G. Mealy, et.al.).

An Information Processing Theory of Verbal Learning, Santa Monica, The RAND Corporation Paper P-1817, October 1959 (Monograph).

Papers (1965-present):

(List organized by topic)

Heuristic DENDRAL Project:

(1) J. Lederberg and E. A. Feigenbaum, "Mechanization of Inductive Inference in Organic Chemistry", in B. Kleinmuntz (ed), Formal Representations for Human Judgment, (Wiley, 1968). (Also Stanford Artificial Intelligence Project Memo No. 54, August 1967).

(2) E. A. Feigenbaum and B. G. Buchanan, "Heuristic DENDRAL: A Program for Generating Explanatory Hypotheses in Organic Chemistry", in Proceedings, Hawaii International Conference on System Sciences, B. K. Kinariwala and F. F. Kuo (eds), University of Hawaii Press, 1968.

(3) B. G. Buchanan, G. L. Sutherland, and E. A. Feigenbaum, "Heuristic DENDRAL: A Program for Generating Explanatory Hypotheses in Organic Chemistry". In Machine Intelligence 4 (B. Meltzer and D. Michie, eds) Edinburgh University Press (1969). (Also Stanford Artificial Intelligence Project Memo No. 62, July 1968.)

(4) E. A. Feigenbaum, "Artificial Intelligence: Themes in the Second Decade". In Final Supplement to Proceedings of the IFIP 68 International Congress, Edinburgh, August 1968. (Also Stanford Artificial Intelligence Project Memo No. 67, August 1968.)

(5) J. Lederberg, G. L. Sutherland, B. G. Buchanan, E. A. Feigenbaum, A. V. Robertson, A. M. Duffield, and C. Djerassi, "Applications of Artificial Intelligence for Chemical Inference I. The Number of Possible Organic Compounds: Acyclic Structures Containing C, H, O and N". Journal of the American Chemical Society, 91:11 (May 21, 1969).

(6) A. M. Duffield, A. V. Robertson, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum, and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference II. Interpretation of Low Resolution Mass Spectra of Ketones". Journal of the American Chemical Society, 91:11 (May 21, 1969).

## BIOGRAPHICAL SKETCH - FEIGENBAUM, Edward A.

## Publications (continued)

- (7) B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum, "Toward an Understanding of Information Processes of Scientific Inference in the Context of Organic Chemistry", in *Machine Intelligence 5*, (B. Meltzer and D. Michie, eds) Edinburgh University Press (1970). (Also Stanford Artificial Intelligence Project Memo No. 99, September 1969.)
- (8) J. Lederberg, G. L. Sutherland, B. G. Buchanan, and E. A. Feigenbaum, "A Heuristic Program for Solving a Scientific Inference Problem: Summary of Motivation and Implementation", Stanford Artificial Intelligence Project Memo No. 104, November, 1969.
- (9) G. Schroll, A. M. Duffield, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum, and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference III. Aliphatic Ethers Diagnosed by Their Low Resolution Mass Spectra and NMR Data". *Journal of the American Chemical Society*, 91:26 (December 17, 1969).
- (10) A. Buchs, A. M. Duffield, G. Schroll, C. Djerassi, A. B. Delfino, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum, and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference IV. Saturated Amines Diagnosed by Their Low Resolution Mass Spectra and Nuclear Magnetic Resonance Spectra", *Journal of the American Chemical Society*, 92 (1970), 6831.
- (11) Y. M. Sheikh, A. Buchs, A. B. Delfino, G. Schroll, A. M. Duffield, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference V. An Approach to the Computer Generation of Cyclic Structures. Differentiation Between All the Possible Isomeric Ketones of Composition C<sub>6</sub>H<sub>10</sub>O", *Organic Mass Spectrometry*, 4 (1970), 493.
- (12) A. Buchs, A. B. Delfino, A. M. Duffield, C. Djerassi, B. G. Buchanan, E. A. Feigenbaum and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference VI. Approach to a General Method of Interpreting Low Resolution Mass Spectra with a Computer", *Chem. Acta Helvetica*, 53 (1970), 1394.
- (13) E. A. Feigenbaum, B. G. Buchanan, and J. Lederberg, "On Generality and Problem Solving: A Case Study Using the DENDRAL Program". In *Machine Intelligence 6* (B. Meltzer and D. Michie, eds.) Edinburgh University Press (1971). (Also Stanford Artificial Intelligence Project Memo No. 131.)
- (14) A. Buchs, A. B. Delfino, C. Djerassi, A. M. Duffield, B. G. Buchanan, E. A. Feigenbaum, J. Lederberg, G. Schroll, and G. L. Sutherland, "The Application of Artificial Intelligence in the Interpretation of Low-Resolution Mass Spectra", *Advances in Mass Spectrometry*, 5, 314.

## BIOGRAPHICAL SKETCH - FEIGENBAUM, Edward A.

## Publications (continued)

- (15) B. G. Buchanan, E. A. Feigenbaum, and J. Lederberg, "A Heuristic Programming Study of Theory Formation in Science." In proceedings of the Second International Joint Conference on Artificial Intelligence, Imperial College, London (September, 1971). (Also Stanford Artificial Intelligence Project Memo No. 145.)
- (16) D. H. Smith, B. G. Buchanan, R. S. Engelmores, A. M. Duffield, A. Yeo, E. A. Feigenbaum, J. Lederberg, and C. Djerassi, "Applications of Artificial Intelligence for Chemical Inference VIII. An Approach to the Computer Interpretation of the High Resolution Mass Spectra of Complex Molecules. Structure Elucidation of Estrogenic Steroids", Journal of the American Chemical Society, 94 (1972), 5962-5971.
- (17) B. G. Buchanan, E. A. Feigenbaum, and N. S. Sridharan, "Heuristic Theory Formation: Data Interpretation and Rule Formation". In Machine Intelligence 7, Edinburgh University Press (1973).
- (18) D. H. Smith, B. G. Buchanan, W. C. White, E. A. Feigenbaum, C. Djerassi and J. Lederberg, "Applications of Artificial Intelligence for Chemical Inference X. Intsum. A Data Interpretation Program as Applied to the Collected Mass Spectra of Estrogenic Steroids." Tetrahedron, 29, 3117 (1973).
- (19) E. A. Feigenbaum, "Computer Applications: Introductory Remarks," in "Proceedings of Federation of American Societies for Experimental Biology," 33, 2331 (1974).
- (20) B. G. Buchanan, D. H. Smith, W. C. White, R. Gritter, E. A. Feigenbaum, J. Lederberg and C. Djerassi, "Applications of Artificial Intelligence for Chemical Inference. XXII. Automatic Rule Formation in Mass Spectrometry by Means of the Meta-DENDRAL Program." Journal of the American Chemical Society, 98:6168, (1976).
- (21) E. A. Feigenbaum, R. S. Engelmores, and C. K. Johnson, "A Correlation between Crystallographic Computing and Artificial Intelligence Research," Acta Cryst. A33 (Jan 1):13-18, (1977).
- (22) H. Penny Nii and Edward A. Feigenbaum, "Rule-based Understanding of Signals," to be presented at Workshop on Pattern-directed Inference Systems, (May 1977).

BIOGRAPHICAL SKETCH - FEIGENBAUM, Edward A.

Publications (continued)

Information Processing Model Building in Psychology:

(1) "Information Processing" in Readiness to Remember: Proceedings of the Third Conference on Remembering, Learning, and Forgetting, Gordon and Breach (1972).

(2) "Information Processing and Memory," Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, Volume 4 (Biology and Health), University of California Press, 1967. Reprinted in Norman, D. (ed.) Models for Memory, Academic Press (1971).

IFIP Congresses:

(1) Invited speech: "Artificial Intelligence: Themes in the Second Decade." In Final Supplement to Proceedings of the IFIP 68 Congress, Edinburgh, August, 1968. Also available as A.I. Project Working Paper No. 67, August 1968.

(2) Report on Panel on the Mechanization of Creative Processes. In Kalenich, W. (ed.), Proceedings of IFIP Congress 65, Volume 2, Spartan Books, 1966, pp. 600-601.

Stanford Computation Center:

"Computers at Stanford," (with N. Nielsen). In Stanford Annual Financial Report Summary, Stanford University, November 1967. Reprinted in IBM Computing Report, Vol. IV, No. 3 (May, 1968), 15-18.

Other:

"Soviet Computer Science, Revisited." Proceedings of the 20th ACM National Conference, August, 1965, pp. 225-226.

Papers, Pre-1965: Available upon request.

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME	TITLE	BIRTHDATE (Mo., Day, Yr.)
JIRAK, Gregory A.	System Programmer	April 24, 1951
PLACE OF BIRTH (City, State, Country)	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date)	SEX
Flagstaff, Arizona, U.S.A.	U.S. citizen	<input checked="" type="checkbox"/> Male <input type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
California Institute of Technology, Pasadena	B.S.	1974	Mathematics (Information Science)

## HONORS

MAJOR RESEARCH INTEREST	ROLE IN PROPOSED PROJECT
Computer systems design	System Programmer, MAINSAIL

## RESEARCH SUPPORT (See instructions)

## RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

- 1976 - present System Programmer, MAINSAIL, SUMEX Computer Project, Department of Genetics, Stanford University
- 1974 - 1976 Scientific Programmer, DENDRAL Project, Instrumentation Research Laboratories, Department of Genetics, Stanford University
- 1973 - 1974 Software Engineer, Image Processing Laboratory, Jet Propulsion Laboratory, California Institute of Technology
- 1971 - 1973 Systems Programmer, Rapidly Extensible Language Project, California Institute of Technology
- 1970 - 1971 Electronic Technician, Sound Master, Inc., Tempe, Arizona
- 1970 System Programmer, IBM 360/25 DOS, Curtis, Woodman & Roach, Inc., Yuma, Arizona
- 1968 - 1969 Junior Programmer, IBM 1401, Data Processing Center, Inc., Yuma, Arizona

PUBLICATIONS (none)



## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME JOHNSON, Suzanne M.	TITLE Scientific Programmer	BIRTHDATE (Mo., Day, Yr.) November 26, 1944
PLACE OF BIRTH (City, State, Country) Pleasantville, New York, U.S.A.	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date) U.S. citizen	SEX <input type="checkbox"/> Male <input checked="" type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
University of Arizona, Tucson	B.S.	1966	Chemistry

## HONORS

MAJOR RESEARCH INTEREST Computer applications in medicine and chemistry	ROLE IN PROPOSED PROJECT Applications Programmer
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## RESEARCH SUPPORT (See instructions)

## RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

- 1974 - present Scientific Programmer, SUMEX Computer Project,  
Department of Genetics, Stanford University
- 1973 - 1974 Scientific Programmer, Center for Radar Astronomy,  
Stanford Electronics Laboratories, Stanford University
- 1971 - 1973 Research Assistant (crystallographic studies/computer data reduction),  
Department of Chemistry, University of Iowa, Iowa City
- 1970 - 1971 Engineer, Geochemistry Section, Lockheed Electronics, Houston, Texas
- 1966 - 1969 Research Assistant (x-ray crystallographer),  
Department of Chemistry, University of Illinois, Urbana

PUBLICATIONS (See continuation page.)

## BIOGRAPHICAL SKETCH - JOHNSON, Suzanne M.

## PUBLICATIONS

1. Johnson, S.M., Newton, M.G., Paul, I.C., Beer, R.J.S. and Cartwright, D.: The Molecular Structure of an Unsymmetrical 6a-Thiathiophthen. *Chem. Commun.*, 1170, 1967.
2. Johnson, S.M., McKecknie, J.S., Lin, B. T-S. and Paul, I.C.: Crystal Structure of Bullvalene at 25°. *J. Am. Chem. Soc.* 89:7123, 1967.
3. Johnson, S.M., Paul, I.C., Rinehart, K.L., Jr. and Srinivasan, R.: The Molecular Configuration of Caldariomycin. *J. Am. Chem. Soc.* 90:136, 1968.
4. Paul, I.C., Johnson, S.M., Paquette, L.A., Barrett, J.H. and Haluska, R.J.: The Molecular Geometry of Derivatives of 1H-Azepine in the Free and Complexed State. *J. Am. Chem. Soc.* 90:5023, 1968.
5. Johnson, S.M. and Paul, I.C.: Crystal and Molecular Structure of [16] Annulene. *J. Am. Chem. Soc.* 90:5555, 1968.
6. Johnson, S.M., Newton, M.G. and Paul, I.C.: Crystal and Molecular Structure of an Unsymmetrical 6a-Thiathiophthen: Single-crystal X-ray Analysis of 3-Benzoyl-5-p-bromo-phenyl-2-methyl-thio-6a-thiathiophthen. *J. Chem. Soc. (B)*, 985, 1969.
7. Paul, I.C., Johnson, S.M., Barrett, J.H. and Paquette, L.A.: The Thermal (6 + 4) $\pi$  Co-cycloaddition of N-alkoxycarbonylazepins: Crystal Structure Analysis of a Derived Monomethiodide. *Chem. Commun.*, 6, 1969.
8. Coates, R.M., Farney, R.F., Johnson, S.M. and Paul, I.C.: The Crystal Structure of Khusimol p-Bromobenzoate. *Chem. Commun.*, 999, 1969.
9. Johnson, S.M. and Paul, I.C.: The Crystal and Molecular Structure of the Perhydromethiodide of an Unsymmetrical N-alkoxycarbonylazepine Dimer. *J. Chem. Soc. (B)*, 1244, 1969.
10. Johnson, S.M. and Paul, I.C.: Crystal and Molecular Structure of 1-Acetyl-1-thionia-5-thia-cyclooctane Perchlorate. *Tet. Letters*, 177, 1969.
11. Leonard, N.J., Golankiewicz, K., McCredie, R.S., Johnson, S.M. and Paul, I.C.: Synthetic Spectroscopic Models Related to Coenzymes and Base Pairs. III. A 1,1'-Trimethylene-Linked Thymine Photodimer of cis-syn Structure. *J. Am. Chem. Soc.* 91:5855, 1969.
12. Sabacky, M.J., Johnson, S.M., Martin, J.C. and Paul, I.C.: Steric Effects in ortho-Substituted Triarylmethanes. *J. Am. Chem. Soc.* 91:7542, 1969.
13. Johnson, S.M., Paul, I.C. and King, G.S.D.: [16] Annulene: The Crystal and Molecular Structure. *J. Chem. Soc. (B)*, 643, 1970.
14. Johnson, S.M., Herrin, J., Liu, S.J. and Paul, I.C.: Crystal Structure of a Barium Complex of Antibiotic X-537A,  $Ba(C_{34}H_{53}O_8)_2 \cdot H_2O$ . *Chem. Commun.* 72, 1970.

## BIOGRAPHICAL SKETCH - JOHNSON, Suzanne M.

## Publications (continued):

15. Johnson, S.M., Herrin, J., Liu, S.J. and Paul, I.C.: The Crystal and Molecular Structure of the Barium Salt of an Antibiotic Containing a High Proportion of Oxygen. *J. Am. Chem. Soc.* 92:4428, 1970.
16. Gibson, E.K. and Johnson, S.M.: Thermal Analysis-Inorganic Gas Release Studies of Lunar Samples. *Proc. Second Lunar Science Conference* 2:1351, 1971.
17. Gibson, E.K. and Johnson, S.M.: Thermogravimetric-Quadrupole Mass-Spectrometric Analysis of Geochemical Samples. *Thermochimica Acta* 4:49, 1972.
18. Carhart, R.E., Johnson, S.M., Smith, D.E., Buchanan, B.G., Dromey, R.G. and Lederberg, J.L.: Networking and a Collaborative Research Community: A Case Study Using the DENDRAL Program. In *Computer Networking and Chemistry* (Ed. Peter Lykos), American Chemical Society Symposium Series, No. 19, 1975.
19. Levinthal, E.C., Carhart, R.E., Johnson, S.M. and Lederberg, J.: When Computers Talk to Computers. *Industrial Research*, November, 1975.

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator.  
Use continuation pages and follow the same general format for each person.)

NAME	TITLE	BIRTHDATE (Mo., Day, Yr.)	
KAHLER, Richard Q.	Scientific Programmer	November 4, 1952	
PLACE OF BIRTH (City, State, Country)	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date)	SEX	
Los Angeles, California, U.S.A.	U.S. citizen	<input checked="" type="checkbox"/> Male <input type="checkbox"/> Female	
EDUCATION (Begin with baccalaureate training and include postdoctoral)			
INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Stanford University (1969-72)	None	--	Electrical Engineering, Computer Science
HONORS			
MAJOR RESEARCH INTEREST		ROLE IN PROPOSED PROJECT	
Subsystem software development, human engineering of user programs, user/project communications		User Consultant	
RESEARCH SUPPORT (See instructions)			

RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

- 1975 - present Scientific Programmer, SUMEX Computer Project,  
Department of Genetics, Stanford University
- 1975 Computer Programmer, Institute for Mathematical Studies  
in the Social Sciences (IMSSS), Stanford University

PUBLICATIONS (none)

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator.  
Use continuation pages and follow the same general format for each person.)

NAME LEDERBERG, Joshua	TITLE Professor and Chairman Department of Genetics	BIRTHDATE (Mo., Day, Yr.) May 23, 1925
PLACE OF BIRTH (City, State, Country) Montclair, New Jersey, U.S.A.	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date) U.S. citizen	SEX <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Columbia College, New York College of Physicians and Surgeons, Columbia Univ., New York (1944-46)	B.A.	1944	Microbiology
Yale University	Ph.D.	1947	

## HONORS

1957 - National Academy of Sciences  
1958 - Nobel Prize in Medicine

MAJOR RESEARCH INTEREST Molecular Genetics, Artificial Intelligence	ROLE IN PROPOSED PROJECT Principal Investigator
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## RESEARCH SUPPORT (See instructions)

(See continuation page.)

## RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

1959 - present Professor and Chairman, Department of Genetics  
Stanford University School of Medicine

1957 - 1959 Chairman, Department of Medical Genetics  
University of Wisconsin

1947 - 1957 Professor of Genetics  
University of Wisconsin

SELECTED PUBLICATIONS (See continuation page.)

## BIOGRAPHICAL SKETCH - LEDERBERG, Joshua

## RESEARCH SUPPORT

Grant No.	Title of Project	Funding		% of Effort	Grant Agency
		Current Year	Project Period		
PERSONAL RESEARCH COMMITMENTS:					
CA16896	Genetics of Bacteria	\$ 80,000 (5/77-4/78 pending)	\$ 464,669 (5/77-4/82)	15	NIH
NAS1-9692	Viking Mission participation	\$ 20,000 (5/77-9/78) (incl. Indirect Costs)	\$ 82,572 (4/70-9/78)	10	NASA
PRINCIPAL INVESTIGATOR EX OFFICIO:					
GMO0295	Genetics Training Grant (graduate research training)	\$111,000 (7/77-6/78)	\$ 538,368 (7/74-6/79)	20	NIH
GM20832	Genetics Research Project	\$266,587 (5/77-4/78)	\$1,292,113 (5/74-4/79)	10	NIH
NGR-05-020-004	Cytochemical Studies of Planetary Microorganisms	\$ 137,500 (9/76-12/77) (incl. Indirect Costs)		3	NASA

## SELECTED PUBLICATIONS

- Lederberg, J.: Topology of Molecules. In The Mathematical Sciences (Ed. Committee on Support of Research in the Mathematical Sciences (COSRIMS) with George A.W. Boehm), MIT Press, p. 37-51, 1969.
- Lederberg, J., Sutherland, G.L., Buchanan, B.G., Feigenbaum, E.A., Robertson, A.V., Duffield, A.M. and Djerassi, C.: Applications of artificial intelligence for chemical inference. I. The number of possible organic compounds. Acyclic structures containing C, H, O, and N. J. Am. Chem. Soc. 91:2973-76, May 21, 1969.
- Buchs, A., Delfino, A.B., Duffield, A.M., Djerassi, C., Buchanan, B.G., Feigenbaum, E.A. and Lederberg, J.: Applications of artificial intelligence for chemical inference. VI. Approach to a general method of interpreting low resolution mass spectra with a computer. Helvetia Chimica Acta 53:1394-1417, 1970.
- Lederberg, J.: Use of Computer to Identify Unknown Compounds: The Automation of Scientific Inference. In Biochemical Applications of Mass Spectrometry (Ed. G.R. Waller), John Wiley and Sons, New York, p. 193-207, 1972.

## BIOGRAPHICAL SKETCH - LEDERBERG, Joshua

## Selected Publications (continued):

5. Lederberg, J.: The freedoms and the control of science - notes from the ivory tower. *Southern California Law Review* 45:596-614, 1972.
6. Lederberg, J.: The control of chemical and biological weapons. *Stanford J. International Studies* 7:22-44, 1972.
7. Lederberg, J.: The genetics of human nature. *Social Res.* 40:375-406, 1973.
8. Lederberg, J.: A System-analytic Viewpoint. In *How Safe is Safe? - The Design of Policy on Drugs and Food Additives*, National Academy of Sciences, Washington, D.C., p. 66-94, 1974.
9. Masinter, L., Sridharan, N., Lederberg, J. and Smith, D.H.: Applications of artificial intelligence for chemical inference. XII. Exhaustive generation of cyclic and acyclic isomers. *J. Am. Chem. Soc.* 96:7702-7714, 1974.
10. Harris-Warrick, R.M., Elkana, Y., Ehrlich, S.D. and Lederberg, J.: Electrophoretic separation of *B. subtilis* genes (EcoR<sub>I</sub>/agarose gel electrophoresis). *Proc. Nat. Acad. Sci. U.S.A.* 72:2207-2211, 1975.
11. Carhart, R.E., Johnson, S.M., Smith, D.H., Buchanan, B.G., Dromey, R.G. and Lederberg, J.: Networking and a Collaborative Research Community: A Case Study using the DENDRAL Programs. In *Computer Networking and Chemistry* (Ed. Peter Lykos), ACS Symposium Series, No. 19, p. 192-217, 1975.
12. Buchanan, B.G., Smith, D.H., White, W.C., Gritter, R., Feigenbaum, E.A., Lederberg, J. and Djerassi, C.: Applications of artificial intelligence for chemical inference. XXII. Automatic rule formation in mass spectrometry by means of the meta-DENDRAL program. *J. Am. Chem. Soc.* 98:6168-6878, 1976.
13. Sagan, C. and Lederberg, J.: The prospects for life on Mars: A pre-Viking assessment. *Icarus* 28:291-300, 1976.
14. Ehrlich, S.D., Bursztyn-Pettegrew, H., Stroynowski, I. and Lederberg, J.: Expression of the thymidylate synthetase gene of the *B. subtilis* bacteriophage phi-3-T in *E. coli*. *Proc. Nat. Acad. Sci.* 73:4145-4199, 1976.
15. Klein, H.P., Lederberg, J., Rich, A., Oyama, V.I. and Levin, G.V.: The Viking Mission search for life on Mars. *Nature* 262:24-27, 1976.
16. Klein, H.P., Horowitz, N.H., Levin, G.V., Oyama, V.I., Lederberg, J., Rich, A., Hubbard, J.S., Hobby, G.L., Straat, P.A., Berdahl, B.J., Carle, G.C., Brown, F.S. and Johnson, R.D.: The Viking biological investigation: Preliminary results. *Science* 194:99-105, 1976.
17. Chi, N-Y. W., Ehrlich, S.D. and Lederberg, J.: Functional expression of two *Bacillus subtilis* chromosomal genes in *Escherichia coli*. *J. Bact.*, 1977. (In press)

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME LEVINTHAL, Elliott C.	TITLE Adjunct Professor of Genetics, Dir., Instrumentation Res. Lab.	BIRTHDATE (Mo., Day, Yr.) April 13, 1922
PLACE OF BIRTH (City, State, Country) Brooklyn, New York, U.S.A.	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date) U.S. citizen	SEX <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Columbia College, New York	B.A.	1942	Physics
Massachusetts Institute of Technology	M.S.	1943	Physics and Math
Stanford University	Ph.D.	1949	Physics and Math

## HONORS

Public Service Medal, awarded by NASA, April, 1977, for exceptional contributions to the success of the Viking project

MAJOR RESEARCH INTEREST Medical instrumentation research	ROLE IN PROPOSED PROJECT AIM Liaison
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## RESEARCH SUPPORT (See instructions)

(See continuation page.)

## RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

1974 - present Adjunct Professor, Department of Genetics, Stanford University;  
Director, Instrumentation Research Laboratory,  
Department of Genetics, Stanford University

1970 - 1973 Associate Dean for Research Affairs,  
Stanford University School of Medicine

1961 - 1974 Senior Scientist/Director, Instrumentation Research Laboratories,  
Department of Genetics, Stanford University

1953 - 1961 President, Levinthal Electronic Products

1952 - 1953 Chief Engineer, Century Electronics

1950 - 1952 Research Director/Member of Board of Directors, Varian Associates

1949 - 1950 Research Physicist, Varian Associates

1946 - 1948 Research Associate, Nuclear Physics, Stanford University

1943 - 1946 Project Engineer, Sperry Gyroscope Company, New York

1943 Teaching Fellow in Physics, Massachusetts Institute of Technology

PUBLICATIONS (See continuation page.)



## BIOGRAPHICAL SKETCH - LEVINTHAL, Elliott C.

## RESEARCH SUPPORT

Grant No.	Title of Project	Funding		% of Effort	Grant Agency
		Current Year	Project Period		
NAS1-9682	Viking Mission participation	\$ 85,000 (11/76-9/77)	\$ 175,552 (11/76-9/78)	50	NASA
NGR-05-020-004	Cytochemical Studies of Planetary Microorganisms	\$ 137,500 (9/76-12/77)		11	NASA
GM20832	Genetics Research Project	\$ 266,587 (5/77-4/78)	\$1,292,113 (5/74-4/79)	8	NIH
RR-00612	Resource Related Research-Computers and Chemistry (DENDRAL)	\$ 213,580 (5/77-4/78)	\$ 698,399 (5/77-4/80)	6	NIH

## SELECTED PUBLICATIONS AND PAPERS

1. Levinthal, E.C.: Detection of Extraterrestrial Life. Professional and Technical Group of Instrumentation and Measurements of IEEE, April, 1963.
2. Levinthal, E.C.: The Detection of Life within our Planetary System. Presented at WESCON, August, 1963.
3. Levinthal, E.C.: The Biological Exploration of Mars. Presented at the Space Technology Laboratory's Invited Lecture Series, November 6, 1963.
4. Levinthal, E.C.: The Biological Exploration of Mars. Presented at Moffet Field, Fullerton, Los Angeles and San Diego, as part of the University of California Extension Series Lectures - Horizons in Space Biosciences: Exobiology, April 27-30, 1964.
5. Levinthal, E.C., Lederberg, J. and Hundley, L.: Multivator - A Biochemical Laboratory for Martian Experiments. Life Sciences and Space Research II, COSPAR (Committee on Space Research), 1964.
6. Halpern, B., Westley, J.W., Levinthal, E.C. and Lederberg, J.: The Pasteur Probe: An Assay for Molecular Asymmetry. Life Sciences and Space Research, COSPAR (Committee on Space Research), 1956.
7. Levinthal, E.C.: Space Vehicles for Planetary Missions. In Biology and the Exploration of Mars, Nat. Acad. Sci., National Research Council.

## BIOGRAPHICAL SKETCH - LEVINTHAL, Elliott C.

## Selected Publications and Papers (continued):

8. Levinthal, E.C.: Prospects for Manned Mars Missions. In Biology and the Exploration of Mars, Nat. Acad. Sci., National Research Council.
9. Reynolds, O., Levinthal, E. and Soffen, G.: The Role of the Scientist in Automated Laboratory Systems. AIAA Paper No. 67-632, 1967.
10. Levinthal, E.C., Lederberg, J. and Sagan, C.: Relationship of Planetary Quarantine to Biological Search Strategy. Presented at COSPAR Meeting (Committee on Space Research), London, 1967.
11. Sagan, C., Levinthal, E.C. and Lederberg, J.: Contamination of Mars. Science 159:1191-1196, 1968.
12. Levinthal, E.C.: The Role of Molecular Asymmetry in Planetary Biological Exploration. Presented at Gordon Research Conferences, Nuclear Chemistry Section, 1968.
13. Kriss, J.P., Bonner, W.A. and Levinthal, E.C.: Variable Time-Lapse Videoscintiscopes: A Modification of the Scintillation Camera Designed for Rapid Flow Studies. J. Nuclear Med. 10:249, 1969.
14. Reynolds, W.E., Bacon, V.A., Bridges, J.C., Coburn, T.C., Halpern, B., Lederberg, J., Levinthal, E.C. and Steed, E.: A Computer Operated Mass Spectrometer System. Anal. Chem. 42:1122, 1970.
15. Masursky, H., Batson, R., Borgeson, W., Carr, M., McCauley, J., Milton, D., Wildey, R. and Wilhelms, D., Murray, B., Horowitz, N., Leighton, R. and Sharp, R., Thompson, W., Briggs, G., Chandeysson, P. and Shipley, E., Sagan, C. and Pollack, J., Lederberg, J., Levinthal, E., Hartmann, W., McCord, T., Smith, B., Davies, M., de Vaucouleurs, G., Leovy, C.: Television Experiment for Mariner Mars 1971. Icarus 12:10-45, 1970.
16. Masursky, H., Batson, R.M., McCauley, J.F., Soderblom, L.A., Wildey, R.L., Carr, M.H., Milton, D.J., Wilhelms, D.E., Smith, B. A., Kirby, T.B., Robinson, J.C., Leovy, C.B., Briggs, G.A., Duxbury, T.C., Acton, C.H., Jr., Murray, B.C., Cutts, J.A., Sharp, R.P., Smith, Susan, Leighton, R.B., Sagan, C., Veverka, J., Noland, M., Lederberg, J., Levinthal, E., Pollack, J.B., Moore, J.T., Jr., Hartmann, W.K., Shipley, E.N., de Vaucouleurs, G., Davies, M.E.: Mariner 9 Television Reconnaissance of Mars and Its Satellites: Preliminary Results. Science 175(4019):294, 1972.
17. Mutch, T.A., Binder, A.B., Huck, F.O., Levinthal, E.C., Morris, E.C., Sagan, Carl and Young, A.T.: Imaging Experiment. Icarus 16:92, 1972.
13. Sagan, Carl, Veverka, Joseph, Fox, Paul, Dubisch, Russel, Lederberg, Joshua, Levinthal, Elliott, Quam, Lynn, Tucker, Robert, Pollack, James B. and Smith, Bradford A.: Variable Features on Mars: Preliminary Mariner 9 Television Results. Icarus 17:346, 1972.

## BIOGRAPHICAL SKETCH - LEVINTHAL, Elliott C.

## Selected Publications and Papers (continued):

19. Levinthal, E.C., Green, W.B., Cuts, J.A., Jahelka, E.D., Johnsen, R.A., Sander, M.J., Seidman, J.B., Young, A.T. and Soderblom, L. A.:  
Mariner 9 - Image Processing and Products. Icarus 18:1088, 1973.
20. Sagan, C., Veverka, J., Fox, P., Dubisch, R., French, R., Gierasch, P., Quam, L., Lederberg, J., Levinthal, E., Tucker, R., Eross, B. and Pollack, J.B.: Variable Features on Mars, 2, Mariner 9 Global Results. J. Geophysical Research 78, No. 20, p. 4153-4196, 1973.
21. Lederberg, J., Feigenbaum, E., Levinthal, E. and Rindfleisch, T.:  
SUMEX - A Resource for Application of Artificial Intelligence in Medicine. Proc. Ann. Conference, Association for Computing Machinery, November, 1974.
22. Levinthal, E.C., Carhart, R.E., Johnson, S.M. and Lederberg, J.: When Computers Talk to Each Other. Industrial Research 17(12):35-42, 1975.
23. Mutch, T.A., Binder, A.B., Huck, F.O., Levinthal, E.C., Liebes, S., Morris, E.C., Patterson, W.R., Pollack, J.B., Sagan, C. and Taylor, G.R.: The Surface of Mars: The View from the Viking I Lander. Science 193(4255):791-801, 1976.
24. Mutch, T.A., Arvidson, R.E., Binder, A.B., Huck, F.O., Levinthal, E.C., Liebes, S., Jr., Morris, E.C., Nummedal, D., Pollack, J.B. and Sagan, C.:  
Fine Particles on Mars: Observations with the Viking I Lander Cameras. Science 194(4260):87-91, 1976.
25. Levinthal, E.C. and Huck, F.O.: Multispectral and Stereo Imaging on Mars. In Astronautical Research 1976 - A New Era of Space Transportation, Pergamon Press, 1976. Proc. of the XXVII International Astronautical Congress, Anaheim, California, 1976.
26. Mutch, T.A., Arvidson, R.E., Aurin, P., Binder, A.B., Huck, F.O., Levinthal, E.C., Liebes, S., Jr., Morris, E.C., Pollack, J.B., Sagan, C. and Saunders, R.: The Surface of Mars: The View from Lander 2. Science 194(4271):1277-1283, 1976.

## BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME	TITLE	BIRTHDATE (Mo, Day, Yr.)
NII, H. Penny	Scientific Programmer	October 6, 1939
PLACE OF BIRTH (City, State, Country)	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date)	SEX
Tokyo, Japan	U.S. citizen	<input type="checkbox"/> Male <input checked="" type="checkbox"/> Female

## EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Tufts University, Jackson College, Medford, Massachusetts	B.S.	1962	Mathematics
Stanford University	M.A.	1973	Computer Science

HONORS

MAJOR RESEARCH INTEREST	ROLE IN PROPOSED PROJECT
Knowledge-based computer systems design	Scientific Programmer - AI tool generalization

RESEARCH SUPPORT (See instructions)

(See continuation page.)

RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

1976 - present Scientific Programmer, Heuristic Programming Project,  
Department of Computer Science, Stanford University

1973 - 1975 Associate Investigator for Computer Science, HASP Project,  
Systems Control, Inc., Palo Alto, California

1967 - 1968 Systems Engineering Advisor, International Business Machines  
World Trade Asia Corporation, Tokyo, Japan

1962 - 1967 Research Staff Programmer, International Business Machines Corporation,  
Thomas J. Watson Research Center,  
1965-67 Project Leader, Electronic Coding Pad (ECP) System  
1965-66 Assistant Manager, Man-Computer Interaction Group  
1963-64 Programmer, World's Fair Lexical Processing System  
1962-63 Programmer, applications ranging from text processing  
to linear programming problems

RECENT PUBLICATIONS (See continuation page.)