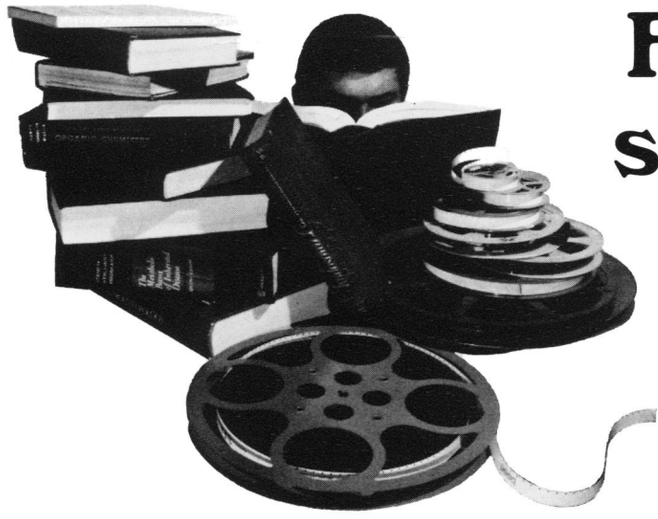
SCIENCE

7 January 1977

Volume 195, No. 4273

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AAAS ANNUAL MEETING—Preconvention Issue



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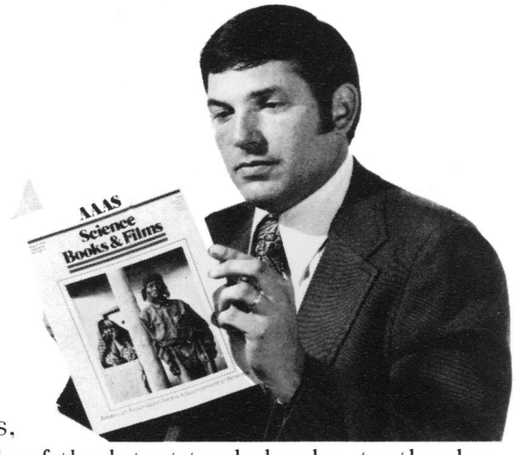

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7 January 1977

Volume 195, No. 4273

SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The American Association for the Advancement of Science was founded in and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress. Postmaster: Send Form 3579 to SCIENCE, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005.

COVER

Uncompahgre National Forest, Colorado. See page 42, AAAS Annual Meeting, 20–25 February 1977. [Jay Higgins, U.S. Forest Service]

Books you should know about....

....from AAAS

RESEARCH AND DEVELOPMENT IN THE FEDERAL BUDGET: FY 1977

by Willis H. Shapley, for the Committee on Science and Public Policy
Retail $5.50. *AAAS member* (prepaid) $4.95.

How are decisions really made on federal funds for research and development? What important changes are being implemented in the Congressional budget process, and how will they affect future R & D budgets? How was the 1977 Federal Budget prepared, and what may happen to it? Few scientists and engineers know the answers to these crucial questions, even though the future of their projects, their programs and institutions, and even whole fields of science or technology are heavily influenced by government funding for R & D. RESEARCH AND DEVELOPMENT IN THE FEDERAL BUDGET: FY 1977 is a report and commentary by an experienced former budget official. It provides current and authoritative treatment of R & D in the federal budgeting process, with important information for scientists, engineers, research institutions, administrators, and students of public policy. In the changing climate of government support for R & D, this book is essential reading!

SCIENTIFIC FREEDOM AND RESPONSIBILITY

by John T. Edsall, for the Committee on Scientific Freedom and Responsibility
Retail $3.45. *AAAS member* (prepaid) $2.95.

Are *you* concerned with the present and future uses and misuses of science and technology? If so, be sure to read this report. It studies and reports on the conditions required to give scientists and engineers the freedom and responsibility to speak out. It prescribes criteria and procedures for the objective and impartial study of conflicts concerning scientific freedom and responsible scientific conduct. And it encourages the development of mechanisms for resolving such disputes. This cogent and meaningful report deals frankly with the value questions facing the scientific and technical communities and does not straddle the hard ethical choices.

CULTURE AND POPULATION CHANGE

A revised edition by Irene Tinker, Priscilla Reining, Warren Swidler, and William Cousins. Preface by Margaret Mead.
Retail $3.50. *AAAS member* (prepaid) $3.00.

This widely read position paper originally was prepared for the World Population Conference held in Bucharest in August 1974. It examines the cultural factors impinging on population matters and points to the need for governments to integrate such factors into their official population policies. The revised edition has been expanded to include a commentary on the World Population Plan of Action formulated at Bucharest. This is an interesting and informative report for everyone concerned with the complex interactions of culture and population policy.

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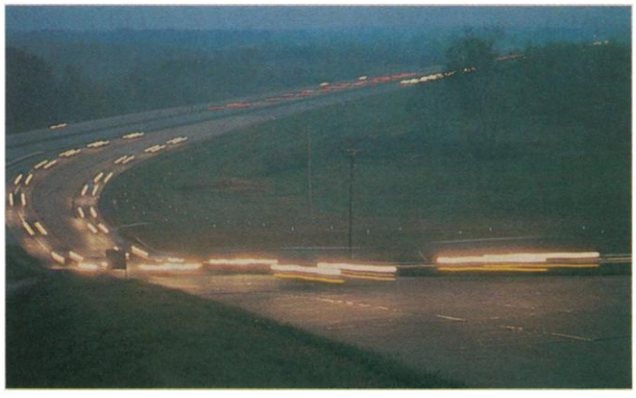


The great sulfate experiment.

Large-scale experimental measurements by the Research Laboratories at General Motors have helped answer an important question in atmospheric science.

Predictions by some scientists had suggested that sulfate emissions from catalyst-equipped cars might reach dangerous levels by 1985. An unlikely occurrence—only under rare atmospheric conditions and if most cars have catalytic converters—but still a possibility, they said.

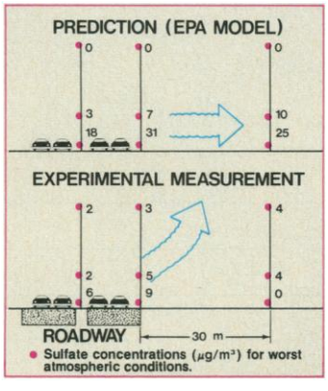
To get hard data, the Research Labs set up "The Great Sulfate Experiment." It was a public test—with the Environmental Protection Agency and other government and university researchers joining in.

Scientific evidence was gathered at the GM Proving Ground by simulating 1985 traffic. During 17 days, a test fleet of 352 catalyst-equipped cars rolled past our six testing towers, creating rush-hour traffic densities of 5,462 vehicles per hour.

During this time, sampling for sulfates and meteorological data took place at 20 points above and at ground level.

The finding: Roadway sulfate emissions are sent aloft by the turbulence and heat generated by vehicles.

It was a key discovery. Atmospheric scientists are now scrapping some old models of dispersion from roadways and drafting new ones based upon this unique data.



What's more, today's catalytic converter system—the best solution we now know for changing some other exhaust pollutants into harmless gases—is still free to do this important job.

If you would like more information on the experiment and its findings, we welcome your inquiry.

General Motors Research Laboratories
Warren, Michigan 48090

7 January 1977, Volume 195, Number 4273 **SCIENCE**

Letters to *Science*

The staff at *Science* strives to be aware of significant events and trends. But each country, state, institution, and department is a composite of diverse microcosms and often life and attitudes within the respective boundaries are those of worlds apart. Our staff opens windows on some of the many worlds by visits, by telephone, and by conversations with knowledgeable people. Of great value to us are various communications from our readers. These often lead to articles, to news stories, and even occasionally to changes in policy. A useful, multipurpose form of communication is the letter to the editor. Among the functions served by the letter are crucial help in quality control of material in the magazine, correction of factual errors, a sampling of reader opinion, and interchange of information among members of the scientific community.

Readers of a magazine called *Science* expect to find accurate information in it. Their expectations are higher for *Science* than for the major news weeklies. When readers find an error they are quick to let us know. This practice has a disciplinary effect on our staff.

Readers of *Science* are drawn from many disciplines and professional connections and they represent the entire spectrum of political beliefs. Thus their letters reflect widely diverse opinions and provide a sampling of a significant segment of society. Some of the letters deal with purely scientific topics that are specialized in nature; they are published as technical comments. Most of the letters, however, deal with controversial science and public policy issues. Scientists are trained to search for the truth. This is relatively simple in the natural sciences. But when public policy is involved truth is elusive, and indeed there may be as many truths as there are people. Thus when controversial material appears in *Science* it often draws an intense and varied response.

About half of such letters, while expressing a strong view, are thoughtful and carefully phrased. The other letters give evidence of being written in anger and in haste. They may contain intemperate remarks, libelous personal attacks, and speculative attribution of evil motivations to others. Publication of some of the material we receive would be a disservice to readers, to writers, and to the magazine.

Each year we receive about 2000 letters and have space to publish less than a fourth of them. In making choices among letters commenting on policy issues, we are guided by some principles. Individuals who feel they have been unfairly treated or misrepresented in *Science* should have an opportunity to express their views. Others, whose perspective differs from that of an author, may feel that an injustice has been done and their thoughts are carefully considered. Since we cannot publish all good letters we must make choices, in which editorial considerations have a role. For example:

1) The shorter and more concise the letter, the greater the chance that it will be selected for publication.

2) Letters should be understandable to all readers of *Science*, with disciplinary jargon avoided.

3) The selection of letters reflects the range of opinions received by the editor. While it is felt that letters from well-known scientists and public figures may especially interest the reader, all letters are given serious consideration.

Letters are edited for style, internal consistency, accurate representation of the article being commented on, and factual and grammatical correctness. Editing of letters is discussed with the letter writer and changes are made with the knowledge and approval of the writer.

The staff of *Science* is grateful for all the letters we receive, even those that are intemperate. After all, there is a fate worse than being criticized. That is, to get no letters at all.—PHILIP H. ABELSON and CHRISTINE KARLIK

Science for Listening

CANCER — the latest in the AAAS audiotape cassette album series.

WHY? This most baffling question is asked every day by over 1000 Americans. Cancer, a disease of fear, anxieties, and of the unknown. A disease that strikes for no apparent reason. Is there an answer? Is there hope? On four hour-long cassettes, science journalists interview 19 leading physicians and cancer researchers. Listen to what the experts in medical science know and the potential that research holds. The newest audiotape album from AAAS is accompanied by a 40-page booklet condensing much of the information contained in the series of tape-recorded narratives. Order the entire package or the booklet alone.

List price: $49.95 Booklet alone: $2.50
(special PREPAID member price: $44.95. Booklet alone: $2.00)

AND NOW . . . for a limited time only, the Association is able to offer its readers the following proven favorites at a special low price to enable you to expand your collection. Which ones do you need for classroom discussions, personal study, or library reference? Look over the list and note how prices have been reduced. Increase your knowledge while we decrease our prices. Order *NOW* while the supply lasts.

☐ **Energy: A Dialogue**

A six-tape album plus booklet which focuses on three major themes: the energy crisis, what it is and how it got that way; the technological options, what they are and how much they will cost; and the interrelationship of energy with environment and politics and how it affects our lifestyles and family budgets.

List price: ~~$49.95~~ $35.00

☐ **Origins**

What is man's deepest mystery? How did life begin? What is the genesis, life, and death of stars? How was the universe created? Four of the world's leading scientists probe these and other questions in *Origins*, an audiotape album with four 50-minute cassettes and accompanying booklet. For the inquisitive mind, for the science student, for anyone who wants to learn more about his own origin or that of his world.

List price: ~~$39.95~~ $30.00

☐ **The Physical World**

Designed for the graduate physicist and other scientists, *The Physical World* contains six lectures selected from presentations at the 14th General Assembly of the International Union of Pure and Applied Physics. The lectures explore such topics as the theory and techniques of scattering methods, the evolution of solid state theory, the various types of nuclear phenomena, as well as questions about how physicists and the lay public can share "the thrill of discovery and the satisfaction of understanding." The accompanying booklet contains reproductions of many of the slides used in the original presentations.

List price: ~~$69.95~~ $55.00

☐ **Speaking of Science**

To help you understand the world through science, AAAS created this three-volume series of audiotapes. Thirty-six conversations between well-known scientists and science writers explore pertinent scientific issues, discoveries and topics of research. Designed for listening both in the home and in the classroom, each volume contains 12 scintillating half-hour conversations certain to spark hours of interesting and informative discussions. The volumes may be purchased separately or in a set. Quantities are limited.

A partial listing of conversations

Volume I: Health Care and Delivery; Technology Today; The Finite Earth.

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Volume II: The Dilemma of Prisons; New Dimensions in Human Genetics; Energy Rationing.

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Science and Change: Hopes and Dilemmas

"You could not step twice into the same rivers, for other and yet other waters are ever flowing," is perhaps one of the less obscure of the surviving fragments of that early Greek philosopher, Heraclitus of Ephesus, some 2500 years ago, in his observations on the primacy of change in nature; observations of little influence in early science with its emphasis on description and classification of what appeared to be immutable. Science, as we have come to know it, blossoming forth out of the 17th century as a means for studying change/process (Newton even invents a new language for describing change, fluxions or calculus, as we now call it), has given us new insights into the nature of what appears to remain unchanged.

Science is the study of change, a study which has proven so effective as to give us the means for controlling some processes in nature and of effecting new changes. Our powers, although still rather meager with respect to the processes of nature, have proven quite formidable with respect to ourselves and our social structures; our world of the 20th century bears little resemblance to that of the 17th. The profound social effects of the changes wrought by science have been both salutary and detrimental; to the degree that the former has prevailed, hopes have risen; the spectre of the latter has only increased fears—the horns of the dilemma of change.

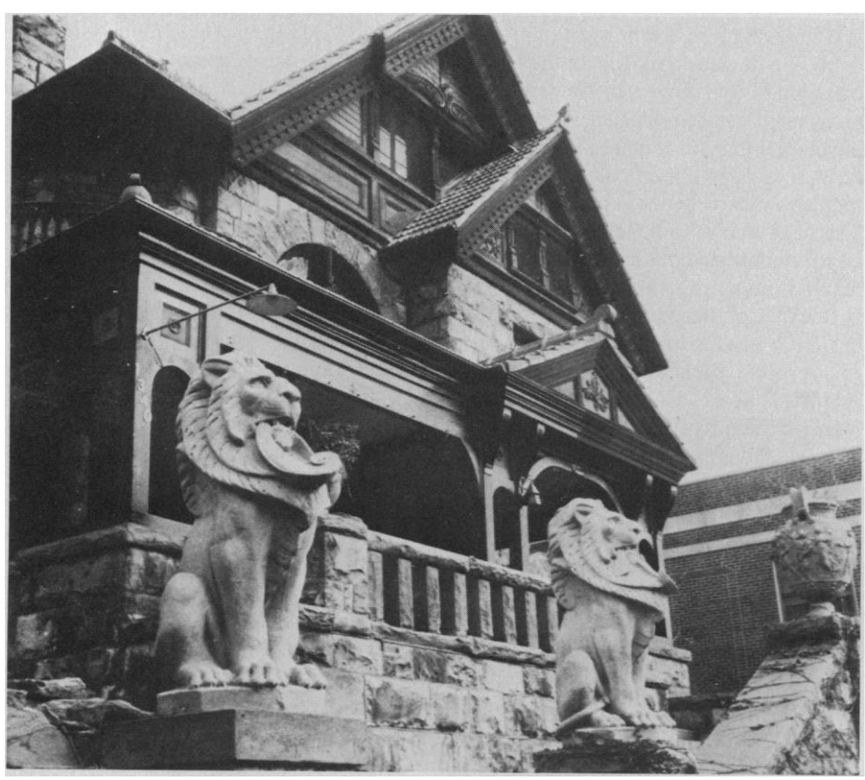
The forthcoming AAAS Annual Meeting in Denver (20 to 25 February 1977) has as its theme: *Science and Change: Hopes and Dilemmas*, and the Meeting Program contains many symposia (listed in the following pages) which explore various aspects of the dilemma of change: the issues in scientific freedom and responsibility, legal questions in weather modification, our political future, the results of our exploration of another world, implications for death, and a host of other topics in 16 subject areas ranging from the physical and mathematical sciences, through energy, environment, and education, to history and philosophy of science. In addition to the 121 symposia, the Meeting features ten public lectures discussing our western heritage, questions of research and of health, and prospects for our environment and for energy.

As a further enrichment of our program this year, with the kind assistance of the AAAS Southwestern and Rocky Mountain (SWARM) Division, meeting with us in Denver, we will have a large number of sessions devoted to contributed papers, both in the traditional slide format and in the new poster format. See page 51 for a schedule of these sessions.

All in all, we modestly believe that we have arranged a truly impressive program for you, one eminently worth your attendance in Denver. In addition to all of this, the Denver Advisory Committee, under the co-chairmanship of Maurice Mitchell (Chancellor of the University of Denver) and John McKinney (President of the Johns-Manville Corporation), has provided an excellent selection of tours and special events (for details, see pages 827 to 829 of the 19 November issue of *Science*). These activities provide a fine survey and introduction to the scientific and ecological resources of the Greater Denver area and, taken with the unsurpassed recreational facilities of Colorado (available for you and your family's post-meeting enjoyment), give yet another good reason to meet with us in Denver this February (the height of the ski season).

Come join us at your Meeting in Denver; add your perceptions to our considerations of the dilemmas of change; partake of the vistas of the Rocky Mountains; broaden all of your horizons.

—ARTHUR HERSCHMAN



Molly Brown House. [Convention and Visitors Bureau of Denver and Colorado]

Annual Meeting
Denver
20-25 February 1977

For information on Tours and Cultural Events see *Science*, 19 November, pages 827 to 829.

Annual Meeting
Denver
20-25 February 1977

Preconvention Program

Science and Change: Hopes and Dilemmas

Public Lectures

- **National Geographic Society Public Lecture (20 Feb., 8:30 p.m., DH).**
  Douglas W. Schwartz (Director, School of American Research, Santa Fe, N.M.).
  The Rio Grande's Pueblo Past.

- **Co-Chairmen's Public Lecture (21 Feb., 1:45 p.m., DH).**
  Richard D. Lamm (Governor of Colorado).
  The Environment and Public Policy.

- **AAAS Public Lecture (21 Feb., 8:30 p.m., DH).**
  Lewis Thomas (President, Memorial Sloan-Kettering Cancer Center, New York, N.Y.).
  Biomedical Science and Human Health: The Long-Range Prospects.

- **AAAS Public Lecture (22 Feb., 1:45 p.m., DH).**
  Mary F. Berry (Chancellor, University of Colorado, Boulder).
  Public Support for University Research: What Is It Worth to Us?

- **AAAS Public Lecture (22 Feb., 8:30 p.m., DH).**
  John A. Eddy (Visiting Fellow, Center for Astrophysics, Harvard College Observatory and Smithsonian Astrophysical Observatory, Cambridge, Mass.).
  Astronomy and the Early Plains Indian.

- **George Sarton Memorial Public Lecture (23 Feb., 1:45 p.m., DH).**
  Jane M. Oppenheimer (William R. Kenan, Jr. Professor of the History of Science, Bryn Mawr College).
  A Biologist Looks at History.

- **AAAS Retiring President's Public Lecture (23 Feb., 8:30 p.m., DH).**
  William D. McElroy (Chancellor, University of California at San Diego).
  Basic and Problem-Oriented Research: A New Emphasis.

- **Phi Beta Kappa Public Lecture (24 Feb., 1:45 p.m., DH).**
  June Goodfield (Visiting Professor, Rockefeller University, New York, N.Y.).
  Humanity in Science: A Perspective and a Plea.

- **John Wesley Powell Memorial Public Lecture (24 Feb., 8:30 p.m., DH).**
  William A. Dick-Peddie (Professor of Biology, New Mexico State University, Las Cruces).
  Safeguarding Our Natural Diversity: The Role of Scientists.

- **AAAS Public Lecture (25 Feb., 1:45 p.m., DH).**
  Peter L. Auer (Professor, Sibley School of Mechanical and Aerospace Engineering, Cornell University).
  Fusion Power—Its Promises and Prospects.

1. General Interest

Case Studies in Scientific Freedom and Responsibility (21 Feb., DH): Critical science, changing perceptions, public participation, Asilomar, education, legal constraints, legislative issues, scientific societies.
William A. Blanpied, Rosemary A. Chalk, Jerome R. Ravetz, Charles Weiner, F. James Rutherford, H. Bentley Glass, Harold P. Green, Charles A. Mosher, Frank Von Hippel.

Technical and Legal Aspects of Weather Modification (22 Feb., DH): Uncertainties, alternatives and prospects, development of the technology, interaction of scientists and lawyers.
Ray J. Davis, Lewis O. Grant, William A. Thomas, Larry Davis, Wayne Decker, Talcott W. Edminster, Ray D. Booker, Frank E. Evans, Conrad E. Keys, Jerome W. Kirby, Carlos Lucero, Stanley A. Changnon, Jr., Harris D. Sherman, G. Brant Foote, James Eastgate, Archie M. Kahan, Joseph D. Howe, Emilio Q. Daddario.

Science: The Key to Our Political Future (22 Feb., DH): Crowded world, world food, raw materials, human habitation and urbanization, fragile environment.
Ian MacGregor, George W. Ball, Charles J. Hitch, Lord Zuckerman.

The Viking Missions to Mars (22 and 23 Feb., DH): Mission profile, geology, surface material, search for motion, weather stations, carbon assimilation, gas exchange, labeled release, organic compounds, inorganic chemistry, physical and magnetic properties, cratering, volcanic processes, fluvial activity, atmospheric phenomena, variable features, polar deposits, martian atmosphere, water, temperatures, Marsquakes.
Carl Sagan, Gerald A. Soffen, James S. Martin, Jr., Thomas A. Mutch, Elliot C. Morris, Alan B. Binder, Seymour L. Hess, Norman Horowitz, Vance Oyama, Gilbert Levin, Klaus Biemann, Priestly Toulmin, III, Richard Shorthill, Robert B. Hargraves, Michael Carr, Ronald Greeley, Harold Masursky, Geoffrey Briggs, Joseph Veverka, James Cutts, Tobias Owen, Michael McElroy, Crofton B. Farmer, Hugh H. Kieffer, Don L. Anderson.

HOTEL CODES: Denver Hilton . . . . . DH; Holiday Inn . . . . . HI; Cosmopolitan . . . . . CO.

The Frontiers of the Natural Sciences (24 Feb., DH): Chemistry, geology, fundamental forces in nature, biological heritage, combinatorial mathematics, astronomy.

Rolf M. Sinclair, John Margrave, Peter J. Wyllie, Chen Ning Yang, James D. Ebert, Ronald L. Graham, Bart J. Bok.

The Right to Die (25 Feb., DH): Death attitudes, function of medicine, definition of death, conflict and responsibility, judicial dilemma, mercy killing, right to live.

Ernan McMullin, Harold A. Widdison, E. Mansell Pattison, Eric Cassell, H. Tristram Engelhardt, Thomas Schelling, Leslie Rothenberg, Kevin O'Rourke, Alasdair MacIntyre, William F. May, Philippa Foot.

2. Physical and Mathematical Sciences

The Promise of High Energy Physics (21 Feb., DH): Building blocks of matter, accelerators, the infinitely small, inside of matter.

Victor F. Weisskopf, Murray Gell-Mann, Robert R. Wilson, Leon M. Lederman.

The New Solar Physics (21 Feb., DH): Seismic sounding, solar neutrinos, streams, sectors, solar magnetism, changing sun.

John A. Eddy, John W. Firor, Henry A. Hill, Raymond J. Davis, Arthur J. Hundhausen.

Science for the Naked Eye: Or the Physics of Everyday Experience, IV (22 Feb., DH): Skiing, biological clocks, lasers and light, karate, meteorology, the violin.

Rolf M. Sinclair, John Howe, Arthur T. Winfree, Arthur L. Schawlow, Michael S. Feld, Ron McNair, David Feld, Jonathan Feld, H. L. Sawatzky, William F. Fry.

Action and Reaction: Science and Mathematics (23 Feb., DH): Computer science, catastrophe theory, duality, infinity.

Daniel J. Sterling, Ottis W. Rechard, Lynn A. Steen, Walter Wyss, Stanislaw M. Ulam.

Quality Mathematical Software (23 Feb., DH): Ordinary differential equations, elliptic partial differential equations, matrix computations.

Cleve B. Moler, Larry F. Shampine, Ronald A. Sweet.

Statistical Problems in the Remote Sensing of Meteorological Parameters (24 Feb., DH): Statistical regularization, microwave radiometric data, meteorological sounding, the cloud problem.

David S. Crosby, Otto N. Strand, Ed R. Westwater, Michael P. Weinreb.

Synchrotron Radiation—A Bright Light for the Biological and Physical Sciences (24 Feb., DH): Muscle structure and dynamics, extended x-ray absorption, metal ion sites in proteins, ultraviolet spectroscopy, x-ray lithography and microscopy.

R. E. Watson, M. L. Perlman, J. B. Hastings, C. Cohen, R. G. Shulman, T. Gustafson, E. Spiller, R. Feder, J. Topalian.

Laser Chemistry (25 Feb., DH): Photochemistry, magnetic resonance studies, free radicals, negative ions, picosecond spectroscopy, anti-Stokes Raman spectroscopy, supersonic molecular beams, isotope separation.

W. Carl Lineberger, C. Bradley Moore, Kenneth M. Evenson, John I. Brauman, Kenneth B. Eisenthal, Albert B. Harvey, Donald H. Levy, Richard Solarz, John Birely.

3. Energy

Wind-Energy Conversion Systems [WECS] (21 Feb., DH): Overview, aerodynamics, Darrieus vertical axis, horizontal axis, small wind energy systems.

Frances J. Laner, Robert N. Meroney, Louis V. Divone, Robert E. Wilson, Richard H. Braasch, Ugo A. Coty, Donald A. Wiederecht.

Geophysical Exploration for Energy and Mineral Reserves (21 Feb., DH): Hydrocarbons, mineral deposits, geothermal reserves.

Franklyn K. Levin, Milton B. Dobrin, John S. Sumner, George V. Keller.

Solar Energy in the 20th Century (22 Feb., DH): Heating, cooling, industrial applications, homes and commercial buildings, remote applications, agricultural and food production applications, solar electric power, central collector systems, distributed systems, orbital systems, utilities.

George W. Morgenthaler, Frances J. Laner, Glen E. Brandvold, Joseph H. Zettel, George O. G. Löf, Sam Primack, Morton B. Prince, Ralph Hansen, Henry H. Marvin, Floyd A. Blake, Cliff Salvage, Aden Meinel, John H. Disher, Chauncey Starr, John Bayless, Saul Ferdman.

The Geologists' Role in the Nuclear Power Cycle (22 Feb., DH): Mineral fuels, uranium mining, siting nuclear facilities, radioactive waste management, radioactive waste disposal.

Hugh R. Wynne-Edwards, Bruce B. Hanshaw, Earl F. Cook, Ron G. Dakars, James F. Devine, G. Lewis Meyer, Ernest E. Angino.

Renewable Energy Resources and Rural Life in the Developing World (23 Feb., DH): Energy needs, solar thermal technologies, photovoltaic technology, wind-energy conversion, hydropower technology, rural electrification, wood waste, methane, alternative energy technologies, economic overview.

Norman L. Brown, William L. Hughes, Roger R. Revelle, George O. G. Löf, Morton B. Prince, S. K. Tewari, Joseph J. Ermenc, Henry A. Arnold, Ibrahim Sakr, J. W. Powell, Raymond C. Loehr, José Miccolis, James A. Crutchfield, Jr.

Nuclear Energy Politics and International Consequences (24 Feb., DH): U.S. perspective, West German position, French perspective, international issues, concerns of Great Britain, Australian position, nongovernmental appraisal.

Valerie Ann Dalski, Nelson F. Sievering, Jr., Klaus W. Wiendieck, Michel A. Chauvin, Dwight Porter, Alan Smith, David G. Walker, John E. Gray.

Nuclear Power and Nuclear Weapons (25 Feb., DH): Strategies for control, agents of proliferation, avoiding proliferation, nuclear export.

Rolf M. Sinclair, Theodore B. Taylor, Herbert F. York, Richard W. Roberts, Thomas D. Davies.

The Fusion Program (25 Feb., DH): Some perspectives, history and physics of fusion, ERDA Program, user's perspective.

Rolf M. Sinclair, Robert L. Hirsch, Edward A. Frieman, Edwin E. Kintner, Clinton P. Ashworth.

4. Resource Policy

Policy Planning for Recreational Land-Use in the Rockies (21 Feb., DH): Making land-use decisions, land-use trade-offs, recreation pricing, public administration, spiritual dimension, consumerism.

Theodore W. Schlie, Russell W. Fitch, David Freeman, Randy B. Boyd, R. Garrett Mitchell, Terrell J. Minger, Rev. Donald Simonton, Janelle Dykes.

Information Credibility and the Mineral Policy Process (21 Feb., DH): Congressional view, limits of the law, private industry's role, the reporter's problem, credibility of information.

John G. Welles, Floyd K. Haskell, Philip J. Mause, Simon D. Strauss, Allen L. Hammond, Eugene N. Cameron.

Energy Conservation—A National Quid Pro Quo (21 Feb., DH): National perspective, conservation legislation, energy requirements, food supply.

John R. Craig, Donald E. Cunningham, Donald Craven, John Steinhart, A. Berry Crawford.

Energy Development in the Rocky Mountain West (22 Feb., DH): Geological perspective, political perspective, environmental perspective, Kaiparowits decision, shale oil devel-

opment, environmental impact, coal mining, coal gasification.
Jerrold H. Krenz, Don L. Boyer, Robert S. Houston, William R. Keefer, Harris D. Sherman, David Freudenthal, John W. Firor, H. Anthony Ruckel, John W. Hand, Katherine Fletcher, C. E. Smith, Jr., Andrew Decorra.

The Impact of Energy Development on Indian Lands (23 Feb., DH): Tribal lands, legal status, water rights, tribal control, economic development.
Tillie Walker, Duane T. Birdbear, Tim Vollmann, John Echohawk, Patrick Stands Over Bull, Peter MacDonald.

Energy from the Rockies: Fueling the Nation or Fouling the States? (23 Feb., CO): Rocky Mountain energy, national needs, environment and energy, alternate energy sources, states' rights.
Thomas L. Wright, John W. Rold, William L. Fisher, Michael McCloskey, Donald A. Henriksen, Richard T. Meyer.

Applied Policy Research: A Review of Energy Resource Development in the Western United States (24 Feb., DH): Western energy development, Southwest regions, technology assessment, status of research.
Irvin L. White, Philip M. Burgess, Joyce M. Kelley, Allen V. Kneese, Lee Brown, R. Leon Leonard, Michael A. Chartock.

5. Biological Science

Herbivore–Secondary Plant Metabolite Interactions (21 Feb., DH): Feeding patterns, plant chemical defenses, cyanogenesis, canavanine-insect interactions, seeds, ecology of the *Cruciferae*.
Gerald A. Rosenthal, Daniel H. Janzen, Rex G. Cates, Eric E. Conn, Paul P. Feeny.

Physiological Reactions in Plants Initiated by Environmental Stress (21 Feb., DH): Membrane form and function, plant hormone systems, metabolic dysfunction, plant function.
M. N. Christiansen, James M. Lyons, R. Hilton Biggs, Charles Y. Sullivan, John C. Brown.

Polar Research: To the Present, and the Future (22 Feb., DH): Emergence of Antarctica, Gondwanaland, polar glaciology, global climate change, polar oceans, productivity, marine mammals, marine ectotherms, adaptations, international perspectives.
Mary A. McWhinnie, Duwayne M. Anderson, Laurence M. Gould, George A. Llano, Campbell Craddock, Richard L. Cameron, George H. Denton, Joseph O. Fletcher, John J. Kelley, Theodore D. Foster, Sayed Z. El-Sayed, Donald B. Siniff, Ian G. Stirling, L. Lee Eberhardt, Arthur L. DeVries, Bruce C. Parker, Robert H. Rutford.

Design of Cell Organelles (23 Feb., DH): Ribosomal architecture, Golgi apparatus, mitochondrial biogenesis, cilia.
Ellen Roter Dirksen, James A. Lake, Becca Fleischer, Ronald A. Butow, Peter Satir.

Science Information: International Communication for Research in Biomedicine (23 Feb., DH): United Kingdom, Western Europe, Canada, Scandinavia, United States, the World System.
Arthur W. Elias, Brian Perry, Rolf Fritz, George Ember, Goran Falkenberg, Mary Corning, Lee Burchinal.

Some Mathematical Questions in Biology (24 and 25 Feb., DH): Wave patterns, compartmentalization, complex systems, nonreciprocating circuits, occluding contour, catastrophe and chaos.
Simon A. Levin, Stuart Kauffman, Ronald Shymko, Kenneth Trabert, Sydney Brenner, Jack Cowan, David Marr, George Oster, Giles Auchmuty, John Guckenheimer.

When Biologists and Mathematicians Work Together: A New Theoretical Biology (25 Feb., DH): Multi-gene families, pattern regulation, community structure.
Charles F. Walter, Daniel L. Solomon, Myron Hood, Lee Hood, Peter Bryant, Stuart Kauffman, Simon A. Levin, Robert Paine.

6. Agriculture and Ecology

Biology and Agriculture in the People's Republic of China (21 Feb., DH): Agricultural ecosystems, biological control of insects, plant disease control.
Arthur Kelman, Jack R. Harlan, Carl B. Huffaker, R. James Cook.

World Food, Pest Losses, and the Environment (22 Feb., DH): Insect pest losses, plant pathogens, weeds, animal pests, social aspects, environmental impact, post-harvest food losses.
David Pimentel, Ray F. Smith, J. Lawrence Apple, W. Furtick, Roger O. Drummond, Ruff Bram, Nels Konnerup, Hans Guggenheim, Max Milner, John R. Pederson.

Coyotes, Wildlife, and Meat Production (23 Feb., DH): Coyote populations, nongame wildlife, wild game, coyote predation, predator damage control, meat production.
Clair E. Terrill, Frederick F. Knowlton, Frederic H. Wagner, Samuel L. Beasom, J. Maurice Shelton, John R. Wood, Carl S. Menzies.

The EQ Index for Wildlife: Blueprint for Survival (23 Feb., DH): Critical water problems, soil resources, forestry, living space, wildlife management.
Donald J. Zinn, Allen V. Kneese, Chester E. Evans, Wayne O. Willis, William E. Towell, Rice Odell, Lee M. Talbot.

Renewable Resource Management for Agriculture and Forestry (24 Feb., DH): Food and fiber, land resources, assessment of technology, energy requirements, institutional restrictions, economic considerations.
James S. Bethel, Martin A. Massengale, Emory Castle, Wynne Thorne, Sylvan Wittwer, William Splinter, George Staebler, Eric Ellwood, John Zivnuska, Del Gardner, Gary A. Ritchie.

High Altitude Geoecology (25 Feb., DH): Physical environment, monitoring, ice and snow, physiology, biology, human occupation.
Patrick J. Webber, Jack D. Ives, Roger G. Barry, Daniel H. Knepper, Malcolm Mellor, Harold W. Steinhoff, Robert F. Grover, W. Dwight Billings, Brooke Thomas.

7. Environment

How Well Are We Equipped to Cope with Environmental Problems? (21 Feb., HI): Environmental policies, adequacy of science and information, industrial perspective, systems ecology, epidemiology, urban planning, legal profession, economics.
William J. Snodgrass, Lynton K. Caldwell, Toufiq A. Siddiqi, Richard Carpenter, Wilson Talley, William J. Coppoc, Don Kash, Gilbert White, Howard T. Odum, Robert N. Hoover, Joachim Tourbier, Charles Conklin, William Schulze.

Benefit-Cost Analysis and Environmental Decisions: Viable Decision Tool or Economists' Pipe Dream? (22 Feb., HI): Alaska pipeline, river development, Tocks Island Dam, pollution, policy tool.
Michael D. Yokell, Charles Cicchetti, Richard Norgaard, Hal Feiveson, Lester Silverman, Alan Carlin.

Nature and Government (23 Feb., HI): Nature and urban concerns, energy policy conflicts, the Front Range, solid waste master plan.
Millard C. Davis, Richard L. James, Ruth W. Melvin, Helen Ross Russell, John E. Martin, Martin Seybold.

The Measurement of Air Pollution (23 Feb., DH): Ozone, remote areas, Clean Air Act, lung health study, SO_2, particulates.
William S. Cleveland, Thomas E. Graedel, James P. Lodge, Stanley M. Blacker, Waynne Ott, Benjamin G. Ferris, Jr., Yvonne M. Bishop, John D. Spengler.

Weather and Geochemistry of the Urban Environment: Process-

es and Impacts—So What! (23 Feb., HI): Severe weather anomalies, inadvertent weather alteration, pollutant measurements in METROMEX, agricultural production, respiratory health study, urban environment.

Richard G. Semonin, Floyd A. Huff, August H. Auer, Jeremy M. Hales, Stanley A. Changnon, Jr., John D. Spengler, Stephen K. Hall, Benjamin G. Ferris, Jr., Harry A. Tourtelot.

Societal and Technical Aspects of Denver Area Air Pollution (24 Feb., HI): Atmospheric chemistry, atmospheric physics, health effects, biological effects, control strategies, national policy.

Edwin F. Danielsen, C. S. Kiang, Francis P. Bretherton, Paul J. Crutzen, John C. Cobb, J. B. Mudd, Myron L. Corrin, Gerard V. Frank, David A. Wagoner, Gary W. Hart, Timothy E. Wirth, Frank Hersman, Kenneth Boulding.

Regional Air Pollution: Truth and Consequences (25 Feb., HI): Atmospheric chemistry and meteorology, health effects, chemistry of precipitation, ecophysiological processes.

William W. Kellogg, Jean French, Ellis B. Cowling, David Tingey, Lawrence C. Raniere.

Environmental Mediation Case Studies (25 Feb., HI): New England, coastal zone of New Jersey, Rocky Mountain region.

Laura M. Lake, Peter B. Clark, Donald B. Straus, Paul Wehr, Christopher Wright, Dorothy Nelkin, Helen Ingram.

8. Arid Lands

American Droughts (21 Feb., DH): History and intensity, agricultural productivity, impacts, strategies, technological options, forecasting.

Norman J. Rosenberg, L. Dean Bark, Richard E. Felch, James E. Newman, Robert D. Miewald, J. Eugene Haas, Stephen H. Schneider.

Scientific Activities Relating to United Nations Conferences: The U.N. Conference on Desertification, September 1977 (21 Feb., DH): Purpose and organization, governmental input, activity and expectations.

Harold Dregne, Priscilla Reining, Mostaffa Tolba, Dean F. Peterson, M. G. C. McDonald Dow, Bill L. Long, Walter Orr Roberts, Irene Tinker, Robert Stein, Robert Kates.

Desert Dust: Origin, Characteristics, and Effect on Man (22 and 23 Feb., DH): Nature, rates of deposition, eolian quartz dust, morphology, duststorms on Mars, oxygen isotopic ratios, dust carried great distances, Asian desert dust, oceanic sediments, climatology and mineralogy, dust transport, effect on weather, effect of erosion and cropping, highway transportation.

Troy L. Péwé, Dan H. Yaalon, Eliezer Ganor, Elizabeth A. Péwé, Richard H. Péwé, André Journaux, David H. Krinsley, Ronald G. Draftz, Jack L. Durham, Ronald Greeley, James Iversen, Bruce White, James Pollack, M. L. Jackson, R. N. Clayton, Dale A. Gillette, Kenneth A. Rahn, Randolph D. Borys, Glenn E. Shaw, Joseph M. Prospero, V. Kolla, James R. Brock, Edwin F. Danielsen, Sherwood Idso, Donald W. Fryrear, David R. Olivarez.

The Reclamation of Disturbed Arid Lands (23 and 24 Feb., DH): Surface mine reclamation, woody plants on mine spoils, native shrubs and oil shale, restoration of productivity, coal reclamation research, aquatic impacts, geochemical aspects, economics, socioeconomic impacts, semiarid mined lands, revegetation, shrub growth, humate deposits, hydrologic design.

Robert A. Wright, Grant Davis, Ardell J. Bjugstad, C. M. McKell, J. F. Power, Fred M. Sandoval, Ronald E. Ries, J. R. Goodin, Ralph P. Carter, Edward H. Dettmann, R. D. Olsen, Donald L. Streib, James R. LaFevers, L. John Hoover, Erik J. Stenehjem, M. L. Riedesel, Richard L. Hodder, A. Perry Plummer, Stephen B. Monsen, Earl F. Aldon, James R. Gosz, Larry L. Barton, Loren D. Potter, Roger E. Smith, David A. Woolhiser.

Social and Technological Management in Dry Lands: Past and Present, Indigenous and Imposed (25 Feb., DH): Cross-cultural survey, indigenous irrigation agriculture, changes in land use, mode of production, ecosystem, desertification, surface water, irrigated agriculture, ethnobotany.

Nancie L. Gonzalez, Anthony Leeds, Theodore E. Downing, Michael E. Moseley, Richard P. Schaedel, Barbara Price, William H. Bedoian, Federico S. Vidal, Susan H. Lees, Richard S. Felger, Priscilla Reining, Stan Ruttenberg, John W. Bennett.

9. Medicine and Health

Health Services for Rural Areas (21 Feb., HI): Family practice center, medical school outreach, community decisions, guidance, incentives.

Bond L. Bible, S. Jack Locke, Ben N. Saltzman, M. Gene Aldridge, Richard M. Spears, Sholom Pearlman.

Mechanisms of Orofacial Motor Control: Masticatory and Speech Functions (21 Feb., HI): Muscle spindle function, biting force, neural mechanisms, nervous system damage.

James H. Abbs, Eric S. Luschei, Louis J. Goldberg, Ronald W. Netsell.

Behavioral Research in Medicine and Health: Careers and Training (22 Feb., HI): Biobehavioral approach, coronary prone behavior, sociocultural approach, interdisciplinary approach, federal role, implications.

Pamela C. Ebert, William Bevan, Henry W. Riecken, Neal E. Miller, David C. Glass, M. Margaret Clark, Carl Pfaffmann, Stephen M. Weiss, David Mechanic.

Organ Transplantation and Tumor Immunity (22 Feb., HI): Kidney as a model, liver transplantation, portal hepatotrophic concept, splanchnic hormones, shared antigens, active immunotherapy, tumor-associated antigens, transfer factor.

Charles W. Putnam, Thomas E. Starzl, Ariel C. Hollinshead, Richard Weil, III, Lawrence Koep, Percy Minden, Evan Hersh, Robert Yonemoto, Barbara Jacobs.

Financial Incentives Promoting Practice in Underserved Areas—Do They Work? (23 Feb., HI): Scarcity area practice, loan forgiveness programs, Illinois' program, Colorado's program.

Ellen P. Sax, Walter J. McNerney, Charles E. Lewis, Jack L. Gibbs, Sholom Pearlman.

Medical Decision-Making (23 Feb., HI): Probabilities, utilities, perceptual inference, cost-benefit analysis.

John A. Swets, Harvey V. Fineberg, Emmett B. Keeler, Milton C. Weinstein, Charles E. Metz, Barbara J. McNeil.

Pharmacokinetics: Implications for Patient Care (23 Feb., HI): Absorption, distribution, metabolism, excretion of drugs, optimizing dosage, therapeutic efficacy, reduction in side effects.

Raymond Jang, John G. Wagner, Thomas F. Patton, Curt R. Freed, Thomas N. Tozer, Stuart Feldman, Michael E. Winter, Clarence T. Ueda.

Scientific Information and Public Policy: Regulating the Use of Psychotropic Drugs (24 Feb., HI): Social dimensions, emerging needs, formulation of policy, legislation, opportunities and barriers.

James J. Bosco, Stanley S. Robin, J. Richard Crout, Carl Taylor, Jane Frank, Keith Connors.

Health Goals and Health Indicators (24 Feb., HI): National health policy, health care needs, health planning, health data, health status indicators, psychological well-being, methodological perspectives.

Jack Elinson, Anne Mooney Hudson, Odin W. Anderson, Samuel Wolfe, Harry Cain, Dorothy P. Rice, Athilia E. Siegmann,

Marilyn Bergner, Norman M. Bradburn, Mata K. Nikias, Thomas W. Bice.

Perinatal Factors and Developmental Hazards (24 Feb., HI): Reproductive casualty, neonatal experience, crib death, taste and smell.

Frances Degen Horowitz, Arnold J. Sameroff, P. Herbert Leiderman, Lewis P. Lipsitt, Trygg Engen, Heinz W. Berendes.

Continuing Evaluation of the Use of Fluorides (25 Feb., HI): Historical perspective, normal fluoride intake, human plasma, caries prevention, osteoporosis, renal clearance, anesthetics, cell cultures.

Erling Johansen, Donald R. Taves, Sholom Pearlman, Reidar F. Sognnaes, Warren S. Guy, Thomas M. Marthaler, Harold C. Hodge, John A. Gray, Jennifer O. Jowsey, Gary M. Whitford, William J. Johnson, Russell A. Van Dyke, John W. Suttie.

10. Anthropology

An Account of the Visual Mode: Man versus Ape (21 Feb., DH): Sign language elements, fingerspelled sequences, technical sign vocabulary, culture and code, sign language and culture, chimpanzees, lowland gorilla.

Fred C. C. Peng, Richard Blasdell, Frank Caccamise, Nancy Frishberg, Gordon W. Hewes, Roger S. Fouts, Francince Patterson.

Effects of Early Experience on Development in Human and Nonhuman Primates (22 Feb., DH): Fear, human affects, langur monkey, first and second siblings, sex roles.

Phyllis C. Dolhinow, Joseph J. Campos, Robert N. Emde, I. Charles Kaufman, James J. McKenna.

Differences in Nutritional Requirements Among and Within Human Populations: Their Significance (22 Feb., DH): Genetic aspects, vitamin E and malaria, Pima Indians and diabetes, sucrose intolerance.

Irving I. Gottesman, Baruch S. Blumberg, John W. Eaton, Peter H. Bennett, H. H. Draper.

Ethnoscience in Native America (23 Feb., DH): Historical overview, ethnobotanical studies, subsistence in Amazonia, mathematical development.

Rayna Green, Richard Ford, Robert Bye, Brent Berlin, Michael P. Closs, Clara Sue Kidwell, Keewaydinoquay Peschel, Joseph Mitchell, Urbiratan D'Ambrosio.

Migration: New Directions and Policy in America (24 Feb., DH): Migration trends, mobility expectations, residential preferences, impacts of migration, migration policy.

Edwin H. Carpenter, Vincent H. Whitney, Glenn V. Fuguitt, James J. Zuiches, Gordon F. DeJong, Peter A. Morrison, Everett S. Lee.

Administration of Fertility Control Programs: A Fourth Dimension (24 Feb., DH): Participative management, community versus clinical approaches, community involvement, rural development programs.

Nirmala Narula, Gaines B. Turner, Allen Jedlicka, David C. Korten, Rolf P. Lynton, Everett M. Rogers, Arch T. Dotson.

Frontiers of Folklore (25 Feb., DH): Context of folklore, performance, enactment, overview.

William R. Bascom, Alan Dundes, Dan Ben-Amos, Harold Scheub, Roger D. Abrahams, Richard Bauman.

American Mountain People (25 Feb., DH): Folk culture, mountain environment, mountain music, storytelling, in-migration.

Stuart M. Leiderman, Ted Landers, Rosemary Landers, Joell Davidson, Sherri Davidson.

11. Technological Implications

Indigenous Scientific and Technological Research in Developing Countries: Where, How Much, What Kind, What Directions? (21 Feb., HI): Issues involved, Indonesia, Mexico, university in the Third World, anthropological research, appropriate technology, village level technology, arid countries.

Dilmus D. James, Allen Jedlicka, James H. Street, Iskandar Alisjahbana, Felino Harahap, Miguel S. Wionczek, J. W. Powell, George N. Appell, Thomas Fox, E. F. Schumacher, A. K. Roy, Robert Bulfin, Millidge Walker, Robert Pierson, Edgar Owens.

Can the Appropriate Technology Movement Really Significantly Enhance Freedom and Quality of Life? (22 Feb., HI): Rural communities, urban communities, enhancing freedom, institutional barriers.

Craig A. Decker, Joseph F. Coates, Mary Ann MacKenzie, David Morris, John Todd, Langdon Winner.

Beyond Gutenberg: Communication Without Paper? (23 Feb., HI): On-Line intellectual community, scientific information, computer-readable data, newly discovered information, integrated communication system.

Harold E. Bamford, Jr., Murray Turoff, William Paisley, Roger K. Summit, David L. Staiger, George K. Chacko.

Hand-Held Calculators—Trends and Impacts (23 Feb., HI): The consumer, calculator technology, educational impact, social implications.

Thomas N. Pyke, Jr., George E. Lindamood, Leonard J. Donohoe, Max S. Bell.

The Consequences of Reduced Building Ventilation (25 Feb., HI): Energy saved, airborne infections, indoor air pollution, sampling in confined atmospheres.

Charles M. Hunt, Tamami Kusuda, George F. Mallison, S. David Shearer, James J. DeCorpo.

Political and Social Aspects of Remote Sensing from Space (25 Feb., HI): Technical capability, international cooperation, international law, politicized science, business view.

George A. Rabchevsky, Roger M. Hoffer, Frederick J. Doyle, James V. Zimmerman, Ronald F. Stowe, Merrill Conitz, Paul M. Maughan.

12. Behavioral Science

Psychoanalytic Research: The Naturalistic and the Experimental Behavioral Science Methods (21 Feb., HI): Nonhuman research, objective-behavioral science approach, gender identity, intuitive approach.

Norman D. Tabachnick, I. Charles Kaufman, Robert J. Stoller, Herbert J. Schlesinger.

Creativity (21 Feb., HI): Emotional blocks, interdisciplinary, sensory imagination, common patterns.

Eileen Sullivan, Milton B. Christian, Eugene Sagan, Sidney J. Parnes, Robert A. McKim, William J. Gordon, Donald J. Koberg.

Individual Differences, Cognition, and Learning (22 Feb., HI): Language processing, individual differences, verbal IQ, information processing.

Wilbert J. McKeachie, James G. Greeno, Michael Cole, Earl B. Hunt, Richard E. Snow.

Values of Screening and Assessment for Early Intervention in the Management of the Special-Needs Child (22 Feb., HI): The

newborn, metabolic disorders, at-risk children, educational planning, issues and policies.

Selcuk T. Sahin, T. Berry Brazelton, Harvey L. Levy, Allen C. Crocker, John H. Meier.

Found: Long-Term Gains from Early Intervention (23 Feb., HI): Center-based studies, New Haven project, sleeper effects, home-based early intervention programs.

Bernard Brown, John H. Meier, Francis H. Palmer, Victoria Seitz, Sheldon H. White, Robert D. Hess.

Toward the Human Use of Human Beings: A Cybernetic Approach to Assessment of Children (23 Feb., HI): Infant-child interaction, psychological testing, cybernetic testing, assessment.

Mark N. Ozer, Frank Baker, T. Berry Brazelton, Irving E. Sigel, Bernard Brown, William Powers.

Families Across the Life Cycle: Issues and Persepctives (24 Feb., HI): Adolescent experience, early marriage, reciprocal socialization, status passage, school-age children, empty nest parent.

Helen K. Grace, Paul A. Reichelt, Kathleen Astin Knafl, Karen Skerrett, Katherine Cavallari Malm, Dorothy Camilleri, Janice K. Janken.

Encounter Groups and Social Change (24 Feb., HI): Search for community, development of communes, humanistic psychology, destructive *gemeinschaft*.

Kurt W. Back, James W. Fernandez, Benjamin D. Zablocki, M. Brewster Smith, Richard Sennett.

Somatosensory Experiences in Infancy and Childhood: Implications for Later Development (24 Feb., HI): Human development, therapeutic techniques, gross motor activities, schizophrenia.

Betty P. Broadhurst, James W. Prescott, Foster W. Cline, Carl R. Guthals, Lorna Jean King, Gordon K. Farley, Jan Vanderburgh.

Violence at Home and at School (25 Feb., HI): Violence toward children, child abuse, family stress, violence and vandalism, classroom violence, reduction of violence.

Rodger W. Bybee, F. James Rutherford, Richard J. Gelles, Brandt F. Steele, Elizabeth Elmer, Donald Bross, Robyn J. Ducharme, C. Henry Kempe, Birch Bayh, Michael Marvin, Tilford Cole, Judy Fruland, Robert Hussey, Madge Zietlow.

13. Education

Research Techniques and Reports by High School Science Students (21 Feb., CO): Reports from students from around the country.

Frank W. Starr, Elemer Bernath, Carol McClain, Linda M. Reider, Anabel W. Preece, Beth Carlberg, Alton Johnson, Rene M. Filipowski, Philip Mitchell, Jayne Thorson, Lynn Fisher, Peter Sandborn, John Spaltro, Randy C. Elliott, Suzanne Kae Chaffee, Robert David Nabow, David Barbour, Roderick Nygaard.

Minorities, Women, and the Handicapped in Science: A Workshop on Programs That Work (21 and 22 Feb., CO.; 23 Feb., DH): Tests, programs: accessibility, funding, evaluation, engineering, biomedicine, science education, ethnoscience, ethnomedicine, handicapped, math anxiety, summer science program, projects that work.

Shirley M. Malcom, Mary Budd Rowe, Janet W. Brown, Luis Nieves, Robert C. Larson, James L. Angel, Nicholas Hobbs, Frederick Fay, Joel Aronson, Phyllis Stearner, John Gavin, S. Maria Hardy, Warren Washington, Doris Hadary, Albert Snow, Rayna D. Green, Robert Menschel, Edward C. Keller, Lucy Sells, Etta Falconer, Lynne Harrington Brown, Stanley G. Sunderwirth, Bernard Kahrahrah, Allan Franklin, Alex Cruz, James Turner, Golden Harris, Caroline Urvater.

Multidisciplinary Training in Science (23 Feb., CO): Ecological problems, energy/environmental problems, the policy world, complexity, science education, societal dimensions, systems analysis.

David Pimentel, George Sprugel, Owen Carroll, David L. Jameson, Richard L. Perrine, Laura M. Lake, Jean Johnson, Kenneth E. F. Watt.

Fungibility: A New Dimension in Biological Curricula (24 Feb., CO): Doctoral education, physical science interface, allied health profession, employment opportunities.

Richard Trumbull, Robert E. Gordon, David M. Gates, Martin D. Brown, George A. Gries.

Implications of Changeover to Metric Measurements (24 Feb., CO): South Africa, international trade, construction trades, the scientist and engineer, metric education, teacher education.

Frances J. Laner, Richard K. Milheim, Joseph M. Lightman, Andrew Lally, William J. Jaffe, Arthur H. Livermore, Vincent G. Sindt.

Public Knowledge of Science—The National Assessment of Educational Progress [NAEP] (25 Feb., CO): General trends, knowledge of science, science assessments.

Ezra Glaser, Robert C. Larson, Mary Budd Rowe, Judith M. Sauls, Norris Harms, Edward C. Bryant, Morris H. Hansen, Arthur H. Livermore, Marie D. Eldridge.

Science, Technology, Policy, and Values: The Interface with Engineering (25 Feb., CO): Technology-policy education, educational goals, government, engineering, industry.

Kan Chen, Robert P. Morgan, Robert W. Dunlap, J. C. Mathes, Joseph F. Coates, David R. Reyes-Guerra, Robert N. Mills, Joshua Menkes, G. Patrick Johnson.

14. Economic and Social Sciences

Prospects for, and Patterns of, Future U.S. Economic Growth (21 Feb., HI): Alternative growth paths, new dimensions, productivity, changing basis for growth, new concept of growth, emerging counter-economy, price system, government intervention, future growth paths.

Robert D. Hamrin, S. Fred Singer, John W. Kendrick, Nathaniel J. Mass, Carl H. Madden, Hazel Henderson, Walter Mead, William D. Nordhaus, Kenneth E. Boulding, Steve H. Hanke.

National and International Cooperation: The Institutional Limits to Growth (22 Feb., HI): National overload, private institutions, the United Nations, global consciousness.

Stephen H. Schneider, C. S. Kiang, Amitai Etzioni, Lewis M. Branscomb, Noel Brown, W. M. Tu, Warren Bennis, Emile Benoit.

Can Research Institutions Accommodate Interdisciplinary Researchers? (22 Feb., HI): Quality review, transdisciplinary science, research universities.

Stephen H. Schneider, Michael H. Glantz, Jerome Weingart, Harrison Brown, Margaret Mead, Lee Schipper.

Technological Change, Progress or Retrogression: Private Benefit Versus Social Cost (23 Feb., HI): Discontinuity, subtle factors, private and social benefit, cure or prevention.

Manoucher Parvin, Thomas Vietorisz, Sanford Bordman, Joseph F. Coates, John Walsh, William T. Hogan, S. J., Melvin Kranzberg, Guillermo A. Calvo.

Environmental Issues and the Social and Behavioral Sciences

(24 Feb., HI): Leisure environments, energy and social issues, the city, identity development and crisis, land use.
Irwin Altman, William R. Burch, Jr., Samuel Z. Klausner, Harold M. Proshansky, Joachim F. Wohlwill.

Covert Discrimination and Women in the Sciences (25 Feb., HI): Individual and the institution, legislative and nonlegislative issues, psychological barriers.
Judith A. Ramaley, Elske Smith, Doris Wooten, Carol Bonosaro, Irene Frieze, Ellen Weaver.

15. Science and Public Policy

Federal Funds for Research: Who Gets What, When, and How? (21 Feb., HI): Budget-making, research organizations, federally funded R & D.
T. Dixon Long, Herman Postma, Walter Rosenblith, Ronald Konkel, Ray Thornton.

Why Run Scared? (21 Feb., HI): Adventure and misadventure, science court experiment, balanced judgment in toxicology.
Homer J. Hall, Anna J. Harrison, Arthur Kantrowitz, Leon Goldberg.

Emerging National and International Policy on Information (22 Feb., HI): Information systems, national copyright policy, computers and communication, responsible computer systems, international information sharing.
Laurence B. Heilprin, Elizabeth B. Adams, Andrew A. Aines, George K. Chacko, Joseph C. R. Licklider, Arthur J. Levine, Donald A. Dunn, Ruth M. Davis, Barbara A. Ringer, Lewis M. Branscomb, Donald G. Fink.

Scientists and Congress: Making a Difference (22 Feb., HI): Congressional agenda, ozone-fluorocarbon controversy, the political arena, congressional science fellowships.
Richard A. Scribner, N. Richard Werthamer, Charles A. Mosher, William Moomaw, Thomas Moss, R. Darryl Banks, Audrey Buyrn, Christopher Coccio, Barry M. Casper.

Knowledge for Policy-Making: Integrating Information, Opinion, and Values (23 Feb., HI): Intermediate knowledge, research applied to national needs, holistic technology assessments.
Richard A. Scribner, Christopher Wright, L. Vaughn Blankenship, Patrick Kelly, Frederick A. Rossini, Don E. Kash, Jack M. Nilles, C. William Fischer, Donald Michael, Steven E. Plotkin.

Judgment and Choice in Public Policy Decisions (23 Feb., HI): Social decision-making, human judgment, societal risk-taking.
Kenneth R. Hammond, Joseph F. Coates, Ward Edwards, Paul Slovic, Kenneth E. Boulding.

The Utilization of Social Science Information by Congress (24 Feb., HI): Social impact assessment, social legislation, social indicators, congressional oversight, evaluating social R & D.
Lawrence Froman, C. P. Wolf, Genevieve J. Knezo, Harrison W. Fox, Jr., Osmund T. Fundingsland, Pamela C. Ebert, Oliver C. Moles, Sally Schurr.

Utilization of Scientific Knowledge in Planning and Implementing Public Policy (24 Feb., HI): Usable social research, relevant scientific data, knowledge utilization, minority students, science policy implications.
Donald C. Pelz, Carol H. Weiss, E. W. Kelley, Nathan S. Caplan, Kiyoshi Ikeda, Robert F. Rich, F. Tomlinson Sparrow, Howard R. Davis.

Energy Analysis: A New Public Policy Tool (25 Feb., HI): Information for policy-makers, environmental work, second law efficiencies, economic costs, energy planning.
Martha W. Gilliland, H. T. Odum, Marc H. Ross, David A. Pilati, Richard H. Williamson.

16. History and Philosophy of Science

Technology and Public Policy: A Retrospective View (21 Feb., DH): The atomic bomb, Jacksonian era relations, submarine telegraphy, the telephone, wastewater systems.
Joel D. Goldhar, David Bearman, Joel A. Tarr, Harvey Brooks, Richard G. Hewlett, Merritt R. Smith, Vary T. Coates, Ithiel de Sola Pool.

Two Martian Centenaries: The Real Moons and the Illusory Canals of Mars (21 Feb., DH): Discovery of the moons, surfaces of the moons, dynamics of the moons, modern observations.
Carl Sagan, Richard Berendzen, Owen Gingerich, Joseph Veverka, Thomas C. Duxbury, George Born, Michael Mendillo, David DeVorkin, Bradford Smith.

Contemporary Religious Movement in America: Religious Minorities in a Secular Society (22 Feb., DH): Religion, secularization and modernization, typology of nontraditional movements, types of conversion, attitudinal changes, social context.
Gillian Lindt, Dick Anthony, Thomas L. Robbins, James T. Richardson, J. Stillson Judah, Benton Johnson, Eileen Barker.

Solutions to Problems Encountered in Running an Academy of Science (22 Feb., CO): Membership drive, Oklahoma, Montana, visiting scientist, fund raising, advisory panel, technical writing, Texas, publications.
Lauren C. Gilman, Lora M. Shields, R. James Becker, Lynn E. Elfner, James F. Lovell, William Brumley, Robert C. Duty, Ruth W. Melvin, Richard J. Raridon, James R. Batt, M. Gabrielle Maze, Robert W. Hanson, George W. Griffith, Michael J. Carlo, Harvey A. Miller.

New Light on Newton: To Honor the 250th Anniversary of His Death (23 Feb., DH): Newton's years of discovery, Newton's dynamics, absolute space, optical lectures, algebraic versus geometric techniques.
Ernan McMullin, Richard S. Westfall, James E. McGuire, Alan Shapiro, Michael Mahoney.

The Epistemic Status of Human Emotions (24 Feb., DH): Animal emotions, children, emotions in human knowing, pictorial communication, emotions and mythology.
Anthony Leeds, John P. Scott, Mathilda S. Holzman, John M. Kennedy, Robert C. Solomon, Wallace L. Chafe, Noretta Koertge.

The Many Faces of Information Science (25 Feb., DH): Information transfer, theoretics of information, information structures, knowledge transfer, signs and symbols.
Edward C. Weiss, William Goffman, Marshall C. Yovits, Naomi Sager, Donald J. Hillman, Vladimir Slamecka.

The General Systems Paradigm: Model for a Changing Science (25 Feb., CO): Reductionism and incrementalism, complementary epistemology, holistic and interdisciplinary approaches.
Heinz Von Foerster, Kenneth E. Boulding, Richard F. Ericson, Joseph Goguen, Hazel Henderson, Margaret Mead, James G. Miller, Anatol Rapoport, Francisco Varela, Ernst Von Glasersfeld.

Race, Sex, and the Maturing of Social Theory (25 Feb., DH): Biological and physical sciences, slavery, family, kinship, racism and sexism.
Eleanor Leacock, Ethel Tobach, Herbert Gutman, Niara M. Sudarkasa, Jessie Bernard.

Meeting Information

Listed below are the Denver hotels which are used by the AAAS for housing and/or program activities during the Annual Meeting. (The two letters in parentheses are the codes that identify session locations in the preconvention program.)

Denver Hilton (DH): Symposia and Public Lectures; Registration, Information, and Ticket Desks; Message Center; Welcome Center (hospitality); Resource Center for the Disabled; Student Hospitality Center; *SCIENCE INTERNATIONAL* (exhibits); *Science Film Festival*; Headquarters Office; Newsroom; Business Meetings.

Holiday Inn—Downtown (HI): Symposia; Business Meetings.

Cosmopolitan (CO): Symposia; Workshops on Minorities in Science; Business Meetings.

Executive Tower Inn: Meeting of the AAAS Southwestern and Rocky Mountain (SWARM) Division; Contributed-Paper (Poster and Slide) Sessions; Registration Desk; AAAS Office and Information Center.

Brown Palace: Housing only.

All the above facilities are located in the downtown area of Denver (for precise locations see map on page 51). Most are within walking distance from one another, but special AAAS shuttle buses will be operated between all hotels.

Registration

Meeting attendees are encouraged to register in advance to obtain a detailed preview of the symposia, lectures, special events, and other activities scheduled during the Meeting. Registration fees are listed on the Registration Form on page 52 in this issue. Please note that special 1-day attendance registration is available on site at the Meeting Registration Desks at $10 (regular) and $5 (student).

Program, badge, and condensed program (foldout) will be mailed to advance registrants on or about 20 January 1977.

On-site Registration Desks will be located in the Denver Hilton (Convention Lobby) and the Executive Tower Inn (Third Floor). Registration hours are as follows:

Sunday, 20 February (*Denver Hilton only*)	2:00 p.m. to 6:00 p.m.
Monday through Thursday, 21–24 February	8:00 a.m. to 6:00 p.m.
Friday, 25 February (*Denver Hilton only*)	8:00 a.m. to 12 noon

Registration Refunds

The AAAS will refund advance registration fees for all cancellations received in writing or by telegram prior to 14 February 1977. NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE. Refunds will be mailed from the AAAS Offices in Washington, following the Annual Meeting.

Tax Deduction for Educational Expenses

Please note that U.S. Treasury Regulation § 1.162-5 permits an income tax deduction for educational expenses (registration fees, and cost of travel, meals, and lodging) undertaken to: (1) maintain or improve skills required in one's employment or other trade or business, or (2) meet express requirements of an employer or a law imposed as a condition to retention of employment, job status, or rate of compensation. This is true even for education which leads to a degree.

Housing

In cooperation with the AAAS, the five Denver hotels used for housing and/or meetings have set aside—at guaranteed reduced rates—blocks of guestrooms for attendees of the Annual Meeting. The Reservation Form on page 53 of this issue lists the participating hotels and their rates. **These rates are guaranteed only when reservations are made through the AAAS Housing Bureau on the official Reservation Form prior to 4 February 1977.**

Hotel rooms are assigned on a first-come, first-served basis. Persons submitting their housing requests late cannot be guaranteed assignment of rooms at the hotel of their choice or at the requested rates. If the room rate specified is no longer available, the next available higher rate will be assigned. If the first choice hotel specified is no longer available, the Housing Bureau will make every effort to assign the second choice requested. Confirmation will come to you directly from the hotel. You should notify the hotel directly of any changes in your reservation. Room assignments will be delayed if any information is omitted from the form.

On request, the hotels will accommodate additional persons in guestrooms (e.g., three persons in a double or twin room). Charges per additional person vary between $5 and $10 per night, depending on the hotel; charges for rollaway beds and cots vary between $2 and $10, depending on the hotel. The Holiday Inn, Executive Tower Inn, and Brown Palace accommodate children under age 12 free of charge in same room with parents. The Cosmopolitan's age limit is 18; the Denver Hilton does not set any age limit.

Resources for Disabled Attendees

The AAAS, in cooperation with the Denver Advisory Committee, is once again making every effort to make the Annual Meeting fully accessible to disabled individuals. In addition to hotel rooms which can accommodate wheelchairs, and accessible meeting areas, the following resources will be available:

- A Resource Center staffed with volunteers to offer assistance on request as part of the hospitality and registration center.
- Shuttle service between meeting hotels in buses or vans equipped with lifts for wheelchairs.
- Transportation service to and from airport, train, and bus stations.
- Interpreters (sign language and oral) at all Public Lectures, and for other sessions on request.
- Repair service for wheelchairs.
- Round-the-clock telephone service responding to emergency needs.
- Special tour and sightseeing information for disabled persons.

The Denver Advisory Committee is making a special effort to ensure that every aspect of the Meeting is barrier-free. Persons needing special hotel accommodations, interpreting services, or other assistance are strongly urged to so indicate on the advance registration and hotel reservation forms. Early response will help us to plan and serve you better. For additional information or suggestions, *contact Martha Redden or Wayne Schwandt, Project on the Handicapped in Science, AAAS, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 (Phone: 202-467-4497).*

Child Care Services

For meeting attendees who require babysitters for infants and small children, or companion care for children 8 years and up, we have obtained the services of **Columbine Sitters (Phone: 303-722-8364).** The agency is open seven days a week, 9:00 a.m. through 9:00 p.m.; 24 hours' notice is requested.

Rates: Initial $1 fee plus $6.50 for the first three hours (includes transportation); $1.50 for every subsequent hour. All sitters are licensed, bonded, and over age 21.

—ELISABETH ZEUTSCHEL

Schedule of Contributed-Paper Sessions

Listed below are the room and time assignments for the various contributed-paper sessions by general topic of the papers. Except where explicitly noted, all sessions are of the traditional slide format. *All contributed-paper sessions will be held in the Executive Tower Inn.*

Monday, 21 February

Education: 9 a.m. and 3 p.m. . . . . .Blue Room
Psychology: 9 a.m. and 3 p.m. . .Curtis/Caucus Room
Biology: 9 a.m. and 3 p.m. . . . . .Brahms Room
Biology: 9 a.m. and 3 p.m. . . . . .Beethoven Room
POSTER (General): 9 a.m. . . . . .Forum Room

Tuesday, 22 February

Education: 9 a.m. and 3 p.m. . . . . .Blue Room
Physics: 9 a.m. . . . . .Tower Room
Chemistry: 3 p.m. . . . . .Tower Room
Psychology: 9 a.m. and 3 p.m. . .Curtis/Caucus Room
Biology: 9 a.m. and 3 p.m. . . . . .Brahms Room
Biology: 9 a.m. and 3 p.m. . . . . .Beethoven Room
POSTER (Medical): 3 p.m. . . . . .Forum Room

Wednesday, 23 February

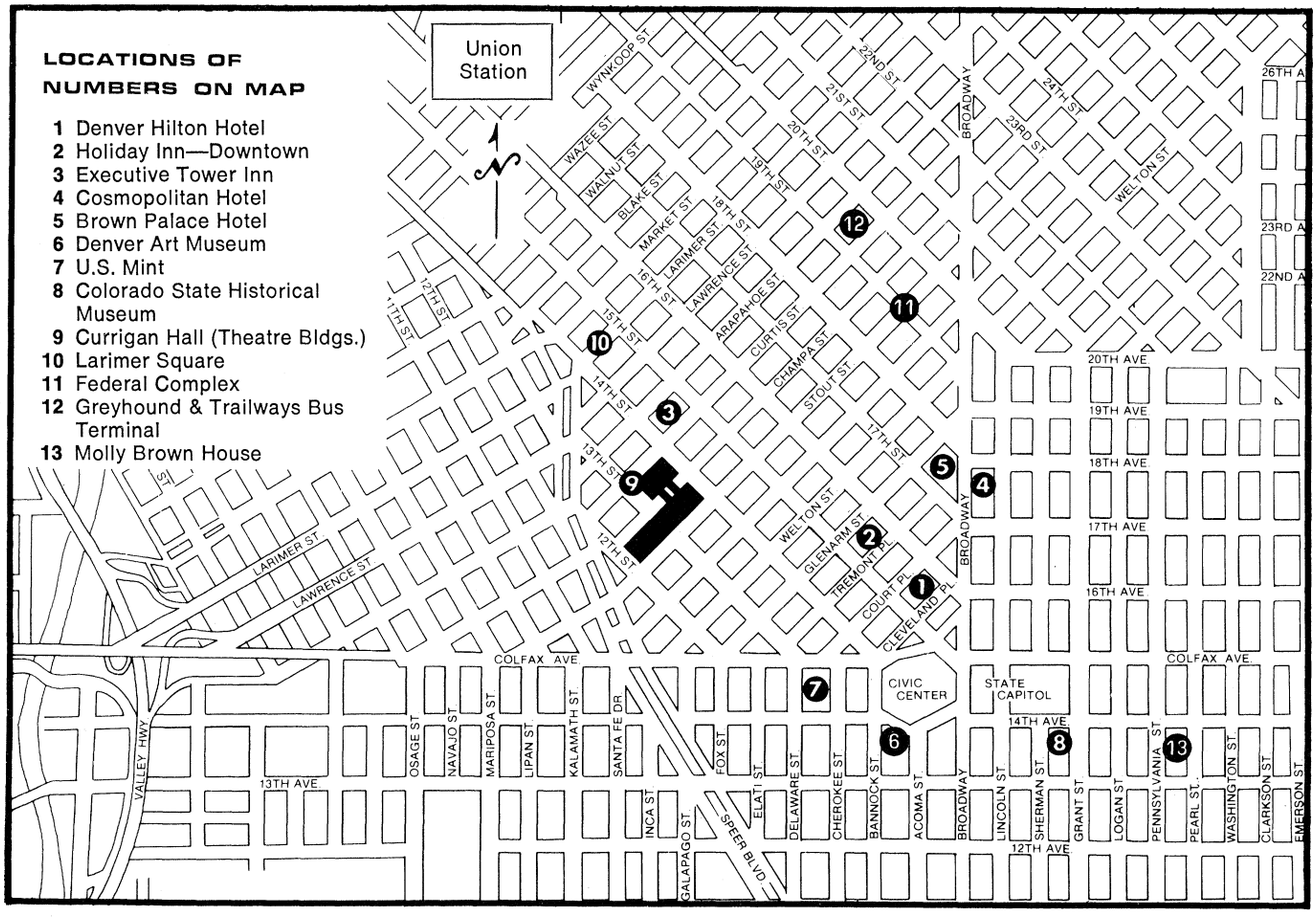
Education: 9 a.m. and 3 p.m. . . . . .Blue Room
Medical: 9 a.m. and 3 p.m. . . . . .Gold Room
Energy: 9 a.m. and 3 p.m. . . . . .Tower Room
Psychology: 9 a.m. . . . . .Curtis/Caucus Room
Anthropology: 3 p.m. . . . . .Curtis/Caucus Room
Biology: 9 a.m. and 3 p.m. . . . . .Brahms Room
Biology: 9 a.m. and 3 p.m. . . . . .Beethoven Room
POSTER (General): 9 a.m. . . . . .Forum Room
POSTER (Psychology): 3 p.m. . . . . .Forum Room

Thursday, 24 February

Education: 9 a.m. and 3 p.m. . . . . .Blue Room
Medical: 9 a.m. and 3 p.m. . . . . .Gold Room
Geology: 9 a.m. . . . . .Tower Room
Information/Statistics: 3 p.m. . . . . .Tower Room
Social/Economic: 9 a.m. and 3 p.m.
. . . . . .Curtis/Caucus Room
Biology: 9 a.m. and 3 p.m. . . . . .Brahms Room
POSTER (Education/Atmospheric and Biology): 9 a.m. and 3 p.m. . . . . .Forum Room

Friday, 25 February

Education: 9 a.m. . . . . .Blue Room
Medical: 9 a.m. . . . . .Gold Room
Atmospheric/Hydrospheric: 9 a.m. . . . .Tower Room
POSTER (Biology): 9 a.m. . . . . .Forum Room



Annual Meeting Denver

20-25 February 1977

Advance Registration Form (E)

ENCLOSED IS:

AAAS Member: ☐ $20 Single Registration Fee ☐ $30 Double Registration Fee (attendee and spouse)

Non-Member: ☐ $25 Single Registration Fee ☐ $35 Double Registration Fee (attendee and spouse)

Non-Member applying for AAAS membership* and meeting registration: (Annual membership dues include 52 issues of SCIENCE. Double membership—individual and spouse—includes one subscription to SCIENCE.)

☐ $45 Single Registration and Membership ($20 registration and $25 dues)

☐ $55 Double Registration and Single Membership (name of applicant_____) ($30 registration and $25 dues)

☐ $67 Double Registration and Membership ($30 registration and $37 dues)

Student: ☐ $10 Single Student Registration Fee ☐ $15 Double Registration Fee (student attendee and spouse)

*These rates apply to USA membership only. Inquire for Canadian or Foreign rates.

Note: Special one-day attendance registration is available at the Meeting Registration Desks ($10 regular, $5 student).

Program and badge will be mailed to each registrant in late January.

Registrations received after 30 January will be held at the AAAS Information Booth.

NAME OF REGISTRANT:_____
(Last Name) (First and Initial)

NAME OF SPOUSE REGISTRANT:_____
(Last Name) (First and Initial)

REGISTRANT'S MAILING ADDRESS:_____
[For receipt of program(s), badge(s), and SCIENCE (for new applicants)] (Street)

_____
(City/State) (Zip Code)

ADDITIONAL REGISTRANTS:_____
(With same mailing address. Use new form if address differs)

_____

REGISTRANT'S INSTITUTION OR COMPANY:_____

_____ ☐☐☐☐☐
(City) (State) (Zip Code)

Check days attending: Sun ☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐

CONVENTION ADDRESS:_____
(Where you can be reached (Hotel or Street Address)

☐ **Please check here if you need special services due to handicap. We will contact you prior to the meeting.**

Mail to: American Association for the Advancement of Science, Dept. R, 1515 Massachusetts Ave., NW, Washington, D.C. 20005

SURVEY OF ATTENDEES
Annual Meeting, Denver, 20–25 February 1977

Your answers to the following questions will help us in planning future AAAS Annual Meetings. Please complete the following form and either return it with your registration form or send in separately (to the same address) if you wish to respond anonymously (in any case, the two forms will be processed separately).

Principal Professional Interest

11 ☐ Physical, mathematical
12 ☐ Biological, medical
13 ☐ Engineering
14 ☐ Social, behavioral
15 ☐ Science policy
16 ☐ ..... (other)

Principal Professional Activity

21 ☐ Teaching, education
22 ☐ Health practice
23 ☐ Other practice, consulting
24 ☐ Research, development
25 ☐ Administration
26 ☐ ..... (other)

Institutional Affiliation Type

31 ☐ University, 4-year college
32 ☐ Other educational
33 ☐ Industrial, commercial
34 ☐ Other private
35 ☐ Government
36 ☐ ..... (other)

Highest Educational Level

41 ☐ Doctoral Degree
42 ☐ Master's Degree
43 ☐ Other professional
44 ☐ Bachelor's Degree
45 ☐ ..... (other)

Age

51 ☐ Under 26 years
52 ☐ 26 to 35 years
53 ☐ 36 to 45 years
54 ☐ 46 to 55 years
55 ☐ 56 to 65 years
56 ☐ Over 65 years

Distance Traveled to Meeting

61 ☐ Under 51 miles
62 ☐ 51 to 100 miles
63 ☐ 101 to 200 miles
64 ☐ 201 to 500 miles
65 ☐ 501 to 1000 miles
66 ☐ Over 1000 miles

Last AAAS Meeting Attended

71 ☐ 1971 in Philadelphia
72 ☐ 1972 in Washington
73 ☐ 1973 in Mexico City
74 ☐ 1974 in San Francisco
75 ☐ 1975 in New York
76 ☐ 1976 in Boston

Reservations

Hotel Rates*

Annual Meeting
Denver
20-25 February 1977

The American Association for the Advancement of Science will hold its 1977 Annual Meeting in Denver, 20–25 February. AAAS headquarters hotel will be the Denver Hilton; the meeting of the AAAS Southwestern and Rocky Mountain Division will be at the Executive Tower Inn, with registration and information desks located at both hotels. Sessions will also be held at the Cosmopolitan and the Holiday Inn—Downtown. The following hotels will be used for housing:

Hotel	Single	Double	Twin	Suites**	Parking
DENVER HILTON *(Headquarters)* 1550 Court Place *(No. of rooms held: 700)*	\$22*** 25 29	\$32 35 39	\$32 35 39	\$104 and up	\$3 per 24 hours
EXECUTIVE TOWER INN *(SWARM)* 1405 Curtis Street *(No. of rooms held: 175)*	\$24	\$30	\$30	\$64 and up	Free 24-hour parking for registered guests
COSMOPOLITAN 1780 Broadway *(No. of rooms held: 200)*	\$18	\$26	\$26	\$125 and up	\$3 (enclosed) and \$2.50 (out-door) per 24 hrs. for registered guests
HOLIDAY INN—DOWNTOWN 15th Street & Glenarm Place *(No. of rooms held: 250)*	\$21	\$26	\$26	\$45 and up	Free for registered guests
BROWN PALACE 321 Seventeenth Street *(No. of rooms held: 50)*	\$34	\$41	\$41	\$65 and up	\$2.50 per 24 hours

*Per day; add 7.5% for State and City Room Tax. Charges for additional persons per room vary between \$5 and \$10, depending on hotel; charges for rollaway beds and cots vary between \$2 and \$10, depending on hotel. Children under age 12 accommodated free in same room with parents at Executive Tower Inn, Holiday Inn, and Brown Palace; age limit higher at Hilton and Cosmopolitan.

**Lowest available rate for one-bedroom/parlor suites; rates for larger suites available upon request.

***One hundred "mini singles" are available at the \$22 rate.

NOTE: If room rate specified is not available, the next available higher rate will be assigned. Confirmation will come to you directly from the hotel. You should notify the hotel of any changes in your reservation. Assignment is delayed if any information is omitted.

HOTEL RESERVATIONS FORM

Please type or print

Reservations received after 4 February cannot be assured.
The Housing Bureau will not accept any reservations by telephone.

CHOICE OF HOTEL: First_____ Second_____

ROOM: ☐ Single ☐ Double ☐ Twin **SUITE:** ☐ 1 Bedroom ☐ 2 Bedrooms Preferred Rate \$_____

Please indicate any special housing needs due to a handicap:

_____

ARRIVAL: Date_____; _____a.m. _____p.m.

DEPARTURE: Date_____; _____a.m. _____p.m.

Be sure to list definite arrival and departure date and time. Hotel reservations will be held only until 6 p.m. unless otherwise specified.

NAMES AND ADDRESSES OF ALL OCCUPANTS OF ROOM

Name _____ Name _____

Address _____ Address _____

City _____ State _____ Zip _____ City _____ State _____ Zip _____

Name _____ Name _____

Address _____ Address _____

City _____ State _____ Zip _____ City _____ State _____ Zip _____

Hotel, confirm reservation to: _____

Mail to: AAAS Housing Bureau
225 West Colfax Avenue, Denver, Colo. 80202

Reports

Chronology of Hawaiian Glaciations

Abstract. *Both potassium/argon and carbon-14 ages of lava flows and tephra layers interstratified with glacial deposits on Mauna Kea, Hawaii, indicate that four episodes of ice cap glaciation culminated about 20,000, 55,000, 135,000, and 250,000 years ago. These episodes are correlated with marine isotope stages 2, 4, 6, and 8, marking times of high global ice volume.*

Although the most dramatic environmental changes brought about by the Quaternary glacial ages occurred in northern middle latitudes where large continental ice sheets repeatedly formed and then disappeared, the effects of global climate change are also evident in tropical latitudes where smaller glaciers developed on some high mountain summits that now lack a perennial ice cover. During the latest glacial ages, a succession of small ice caps formed at the crest of Mauna Kea, the highest of Hawaii's volcanoes and the only known glaciated peak in the central Pacific Ocean basin. Because the massive shield of Mauna Kea was being actively constructed during this interval, glacial sediments are interstratified with lava flows and pyroclastic deposits on the upper slopes of the volcano. Recent radiometric dating of volcanic rocks and sediments directly associated with sheets of glacial drift makes possible an assessment of the ages of four recognized glaciations and provides a basis for comparing the resulting terrestrial glacial chronology with a record of late Pleistocene climatic fluctuations inferred from isotopic studies of deep-sea cores.

The exposed rocks on Mauna Kea are divisible into two lithologic groups, an older tholeiitic assemblage that constitutes the bulk of the volcanic pile and a younger differentiated alkalic suite that forms a thin carapace over the crest of the main shield (*1*). The older rocks, comprising the Hamakua Group, consist largely of thin but extensive pahoehoe flows of basalt and olivine basalt, whereas the younger rocks, included in the Laupahoehoe Group, are predominantly thick, type aa flows of hawaiite, with alkalic olivine basalt, ankaramite, and mugearite present in smaller volume. Pyroclastic cones and tephra layers form an important part of the Laupahoehoe section, especially along the principal rift zones (*2*).

Further subdivision of the stratigraphic sequence is based on the occurrence of glacial sediments within the volcanic pile. The recognition of four such horizons on the upper slopes of the mountain has led to the designation of seven formations (Figs. 1 and 2) (*1*). Clasts within the oldest exposed glacial drift, the Pohakuloa Formation, consist largely of vesicular olivine basalt of the Hamakua Group. The formation includes both diamicton and fluvial facies interpreted as till and outwash, respectively (*3*). It is exposed in several deep gulches on the south side of the volcano where basal sediments locally rest on abraded flows of the underlying Hopukani Formation.

Glacial sediments of the Waihu Formation form a belt of subdued end moraines that are exposed mainly in the southwest quadrant of the volcano at the 3000-m level; elsewhere they have been buried by younger lava flows. The drift includes clasts derived both from the Hopukani Formation and from the Liloe Formation which separates the Waihu deposits from the underlying Pohakuloa drift. The end moraines contain basal till and flow till as well as meltwater sediments, and they are associated with extensive outwash gravels that mantle the southwestern slope of the mountain above the Mauna Kea–Mauna Loa saddle. Abraded rock pavements are found locally beneath basal Waihu till and display striations oriented perpendicular to the gross topographic contours of the mountain. Surface boulders of Waihu age are deeply pitted or exfoliated, and tor-like pinnacles of indurated drift standing as much as 3 m above the surface of Waihu moraine crests suggest that the unit is substantially older than the comparatively unweathered and little-eroded drifts of Makanaka age.

Moraines of the Makanaka Formation, consisting largely of hawaiite clasts, can be traced almost continuously around the mountain at the 3500-m level. Where they border major gulches, the massive steep-sided lateral moraines reach heights of 50 m. Upslope from the end moraine belt extensive striated pavements are developed on aa lavas from which surface flow rubble has been stripped away by glacial ice. The Makanaka Formation is divisible into two units of glacial origin (Upper Member and Lower Member), separated by lava flows of the nonglacial Kemole Member. These lava flows are restricted largely to the principal rift zones where they are associated with numerous cinder cones and widespread tephra layers. End moraines of early Makanaka age commonly overlie lavas of the Hanaipoe Formation and extend only slightly beyond the more massive moraines of late Makanaka age. Only subtle differences in the degree of weathering are detectable between the two groups of moraines, suggesting that the Kemole interval probably was interstadial, rather than inter-