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The History of the Cell Sorter Videohistory Collection, 1991

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Collection Overview

Repository:	Smithsonian Institution Archives, Washington, D.C., *osiaref@si.edu*
Title:	The History of the Cell Sorter Videohistory Collection
Identifier:	Record Unit 9554
Date:	1991
Extent:	7 videotapes (Reference copies). 12 digital .wmv files and .rm files (Reference copies).
Creator::	
Language:	English

Administrative Information

Prefered Citation

Smithsonian Institution Archives, Record Unit 9554, The History of the Cell Sorter Videohistory Collection

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Restricted. "Inventing the Cell Sorter" film cannot be reproduced. Contact SIHistory@si.edu for more details.

Historical Note

The cell sorter, an instrument with sophisticated optics, lasers and electronic processors, automated the task of identifying and quantitatively analyzing individual cells, and of separating and rapidly sorting closely related cell populations. By measuring the physical and chemical properties of cells, such as fluorescence, then by physically separating cells while still alive, the cell sorter became an important tool for biomedical research and clinical medicine.

The first prototype sorter was built at the Los Alamos National Laboratory (LANL) in 1965 by physicist Mack J. Fulwyler by joining a Coulter volume sensor with the newly-invented ink jet printer. The first biologist who clearly saw uses for the Los Alamos instrument, especially for the study of immunological properties of cells, was Leonard Herzenberg of Stanford University. With Fulwyler's plans, Herzenberg obtained the cooperation of engineers in the Genetics Department's Instrumentation Research Laboratory at Stanford to build an instrument to sort live cells using fluorescence. Two successful prototypes were built -- a 1969 instrument that employed a mercury arc lamp as light source and a 1972 version which used an argon ion laser to detect cells tagged with fluorescent markers. Funding from the National Institutes of Health (NIH) allowed Herzenberg and the Stanford engineers to interest the medical products company Becton Dickinson (BD) to convert their prototypes into the first commercial instruments, the FACS (Fluorescence Activated Cell Sorter) in 1975.

Interviewees included scientists, engineers, managers, and physicians from Becton Dickinson Immunocytometry Systems (BDIS), Stanford University, Brown University, and LANL. Bruce Allen Bach received his B.S. in biology and his M.A. in molecular biology from Stanford University in 1973 and 1974, respectively. He was awarded his Ph.D. in immunology from Harvard Medical School in 1979 and a M.D. from the Washington University School of Medicine in 1981. After completing his residency at the University of California Affiliated Hospitals, Bach accepted the position of Associate Scientific Member of the Howard Hughes Medical Research Institute in 1984. From 1985 to 1987 he served as a physician at two San Francisco area hospitals. In 1989, he was appointed Corporate Medical Director of BDIS, and held that position concurrently with his 1991 appointment as director of BD's worldwide clinical trials group.

Mack Jett Fulwyler received his B.S. in physics from Idaho State College in 1961 and his Ph.D. in biophysics from the University of Colorado in 1969. From 1961 to 1967, Fulwyler worked at LANL where he developed particle separators and sorters. In 1971, he accepted the position of President of Particle Technology, Inc. In 1977, after completing a two year fellowship at the Max Planck Institute in Germany, Fulwyler returned to the U.S. to serve as Technical Director for BD FACS System Division. He retired from that position in 1982 and accepted a professorship at the University of California, San Francisco. Since 1990, Fulwyler served as Director of Technical Development for the Trancel Corporation.

After receiving his B.A. in biology and chemistry from Brooklyn College in 1952 and his Ph.D. in biochemistry and immunology from the California Institute of Technology in 1955, Leonard A. Herzenberg accepted a postdoctoral fellowship from the American Cancer Society to conduct research at the Pasteur Institute in France. Herzenberg returned to the U.S. in 1957 to serve as an officer for the Public Health Service at the National Institutes of Health. In 1959, he accepted the position of Assistant Professor in the Department of Genetics at Stanford University and was eventually appointed Professor of Genetics.

Leonore A. Herzenberg attended classes at Pomona College and the California Institute of Technology during the mid-1950s. In 1981, she was awarded the degree of Docteur des Sciences Naturelles from the Sorbonne University in Paris. During the 1950s, she served as a research assistant at the California Institute of Technology, the Pasteur Institute, and the National Institutes of Health. In 1959, she accepted the position of Research Assistant in the Department of Genetics and the Department of Obstetrics and Gynecology at Stanford University. Subsequently, she was appointed Senior Research Assistant in those departments in 1963 and Research Associate in 1967. From 1973 to 1989, she worked as a Research Associate and Senior Research Associate solely in the Department of Genetics. In 1989, she was appointed professor in the Genetics Department.

Mark A. Krasnow received his B.S. in biology and chemistry from the University of Illinois in 1978. He was awarded his Ph.D. in biochemistry in 1983, and his M.D. in 1985, from the University of Chicago. In 1988, he was appointed Assistant Professor in the Department of Biochemistry at the Stanford University School of Medicine. His research interests include the biochemical mechanisms of transcriptional regulation and cell to cell interactions in the development of Drosophila.

Nagesh S. Mhatre, president of BDIS, was awarded a B.S. from Bombay University, an M.S. from Oregon State University, and a Ph.D. in biochemistry-microbiology from Rutgers University. Before being appointed president in 1983, Mhatre held a variety of positions with Becton Dickinson & Company. Previously, he was with Miles Laboratory for seventeen years.

After receiving his B.S. in biochemistry from the University of California, Berkeley, in 1986, Monty Montano conducted research at the University of California, San Francisco on the use of recombinant DNA applied to clinical genetics. Montano began a doctoral program in genetics at Stanford University in 1988.

Wayne A. Moore received his B.S. in mathematics and science from Stanford University in 1976. From 1972, he worked as a lab assistant and programmer at the Stanford Department of Genetics and was later appointed Senior Scientific Programmer of that department.

From 1970 to 1974, Thomas Nozaki, Jr., served as an electronics engineer at the Stanford Computation Center. After receiving his B.S. in electrical engineering from California State University in 1974, Nozaki joined the Stanford Department of Genetics as a research and development electronics engineer.

Richard E. Owen, Director of Instrument Operations for BDIS, joined the company in 1988 as Manufacturing Engineering Manager. Prior to joining BDIS, he was Director of Thorn EMI Datatech Ltd. in England. He holds a Higher National Certificate in Applied Physics from Southeast London Technical College, a B.A. in Management from St. Marys College in Moraga, California, and is a graduate of the Institute of Electronic and Radio Engineers.

David R. Parks received his B.S. from Grinnell College in 1967, and his Ph.D. in physics from Stanford University in 1973. From 1973 to 1974 he worked as a Field Assistant and Project Manager in environmental studies at the Missouri Botanical Garden. In 1975, he returned to Stanford University as a postdoctoral fellow in the Department of Genetics. In 1981, he accepted the position of Research Associate in that department and held that position concurrently with his appointment as director of the Shared Cell Sorter Facility in 1983.

In 1981 Diether J. Recktenwald joined BDIS as a Senior Research Scientist; he was appointed research group leader and later associate scientific director. Prior to BDIS, he was a visiting scientist at Stanford University and a senior research associate at the Max Planck Institute. He received a Ph.D. in biochemistry and biophysics from Ruhruniversitat Bochum in Germany, and an M.S. and B.S. from Universitat des Saarlandes Saarbrucken, also in Germany.

Marcos Boris Rotman received his M.S. in chemical engineering from the University F. Santa Maria in Chile in 1948, and his Ph.D. in microbiology, organic chemistry, and biochemistry from the University of Illinois in 1952. After completing his degree, he served a year as a research associate at the University of Illinois, and then moved to the University of Wisconsin to work in the laboratory of Joshua Lederberg from 1953 to 1956. In 1959, Rotman became Assistant Professor in the Department of Biochemistry at the Albany Medical School, and in 1961 moved to the Department of Genetics at Stanford as a Research Associate. From 1961 to 1966, he served as head of the biochemistry section of the Syntex Institute for Molecular Biology, located at Stanford. In 1966, Rotman left Stanford to become professor of Medical Science at Brown University. In 1990, he was awarded the title of Professor Emeritus.

Bernie Shoor completed his B.A. in physics from New York University in 1946. After receiving his degree, he worked for the Army Signal Corps and subsequently the Sperry Gyroscope Company. In 1966, Shoor began working for Endevco Corporation, a small scientific instrument company which was eventually bought by BD. In 1970, Shoor became manager of BD's Mountain View, California, laboratory. In 1977, he accepted the position of Corporate Vice-President of Research and Design at BD's headquarters in New Jersey. In 1981, he returned to California to establish the BD Monoclonal Center. Shoor retired from BD in 1984 but has continued to serve as a consultant for the company.

After receiving his B.S. in mechanical engineering in 1965, and his M.S. in theoretical and applied mechanics in 1967 from Cornell University, Richard T. Stovel worked as a Research Engineer at Lockheed Missiles and Space Company analyzing the structural dynamics of missile systems. In 1972, he joined the Stanford University Department of Genetics as a Physical Science and Engineering Technician working on the operation and development of the prototype cell sorting machine. In 1976, he was appointed Research and Development Engineer of the Genetics Department where he continued his research in fluid jet behavior.

Richard G. Sweet received his B.S. in electrical engineering in 1947. From 1947 to 1951, he worked as a design engineer on telephone systems at the Southern California Edison Company. In 1951, he accepted the position of Senior Design Engineer at Gilfillan Bros. Inc., developing electronics equipment for radar systems. Sweet joined Stanford University Electronics Labs in 1956 as a research associate where he developed, most notably, high speed ink jet recording systems. After a decade at Stanford, Sweet accepted the position of Senior Engineer at Varian Associates in 1966 and worked on developing

instrumentation for classifying and sorting small particles. In 1971, he travelled as a visiting scientist to the Xerox Palo Alto Research Center to conduct research on non-impact printing systems. Since 1986, Sweet has served as a consultant to both the Herzenberg Laboratory and to BDIS.

After receiving his B.S. from City College of New York in 1939 and his Ph.D. in physics from Massachusetts Institute of Technology in 1951, Marvin A. Van Dilla worked in the radiobiology laboratory at the University of Utah. In 1957, he joined the Los Alamos Scientific Laboratory as the biophysics group leader. Van Dilla left Los Alamos in 1972 to become the cytophysics Section Leader of the Biomedical Sciences Division at Lawrence Livermore Laboratory. In 1983, he was appointed Leader of the Gene Library Project at Livermore.

Nicholas Veizades was awarded his B.S. in electrical engineering from the University of California, Berkeley in 1958, and his M.S. in engineering sciences from Stanford University in 1961. He joined the Stanford Department of Genetics in 1962 and worked in the Instrumentation Research Laboratory on biomedical instrumentation.

Introduction

The Smithsonian Videohistory Program, funded by the Alfred P. Sloan Foundation from 1986 until 1992, used video in historical research. Additional collections have been added since the grant project ended. Videohistory uses the video camera as a historical research tool to record moving visual information. Video works best in historical research when recording people at work in environments, explaining artifacts, demonstrating process, or in group discussion. The experimental program recorded projects that reflected the Institution's concern with the conduct of contemporary science and technology.

Smithsonian historians participated in the program to document visual aspects of their on-going historical research. Projects covered topics in the physical and biological sciences as well as in technological design and manufacture. To capture site, process, and interaction most effectively, projects were taped in offices, factories, quarries, laboratories, observatories, and museums. Resulting footage was duplicated, transcribed, and deposited in the Smithsonian Institution Archives for scholarship, education, and exhibition. The collection is open to qualified researchers.

Descriptive Entry

Ramunas Kondratas, curator at the Smithsonian's National Museum of American History (NMAH), documented the history, development, commercialization and applications of fluorescence activated cell sorting instrumentation. Sessions were recorded January 30, 1991 at San Jose, California; February 1, 1991 at Palo Alto, California; April 19, 1991 at Washington, D.C.; and June 28, 1991 at Providence, Rhode Island.

Several participants were also interviewed on audiotape. They include Bach, Christiaanse, Fulwyler, Leonard Herzenberg, Leonore Herzenberg, Kudravcev, Mhatre, Recktenwald, Rotman, Shoor, and Van Dilla. The audiotapes and transcripts complement the videotape sessions and are available through the Division of Medical Sciences, National Museum of American History. *Inventing the Cell Sorter*, an edited program on the history of the machine, accompanies the collection as supplemental material. This tape, *Inventing the Cell Sorter*, may not be copied without the permission of Ramunas Kondratas.

This collection consists of four interview sessions, totalling approximately 10:20 hours of recordings and 203 pages of transcript.

Audiotapes: Several participants were also interviewed on audiotape. The audiotapes and transcripts complement the videotape session, and are available through the Division of Medical Sciences, National Museum of American History.

Names and Subject Terms

This collection is indexed in the online catalog of the Smithsonian Institution under the following terms:

Subjects:

AIDS (Disease)
Bioengineering
Biology
Biotechnology
Cell separation
Cytometry
Flow cytometry
Fluorescence activated cell sorter
Interviews
Medicine
Molecular biology
Oral history
Science -- History
Scientific apparatus and instruments
Separation (Technology)
Technology -- History

Types of Materials:

Transcripts
Videotapes

Names:

Bach, Bruce Allen
Becton Dickinson, Inc.
Fulwyler, Mack Jett
Herzenberg, Leonard A.
Herzenberg, Leonore A.
Kondratas, Ramunas A., interviewer
Krasnow, Mark, 1956-
Los Alamos Scientific Laboratory
Mhatre, Nagesh S.
Montano, Monty
Moore, Wayne A.
Nozaki, Thomas, Jr.
Owen, Richard E.
Parks, David R.
Recktenwald, Diether J.
Rotman, Marcos Boris
Shoor, Bernie
Stanford University
Stovel, Richard T.
Sweet, Richard G.

Van Dilla, Marvin A.
Veizades, Nicholas

Container Listing

Interviews

Interviews **Session 1: January 30, 1991**

Interviews Was recorded at Becton Dickinson Immunocytometry Systems (BDIS). Mhatre, Shoor, Bach, Owen, and Recktenwald discussed the history and development of the FACS machine, as well as its commercial manufacture by Becton Dickinson and its clinical applications, c. 1900-1991, including: History of Becton Dickinson and Company; equipment manufactured by BD; collaboration with Stanford in building a cell sorter; design and construction of early sorters; development of BDIS; discovery of monoclonal antibodies; development of the BD Monoclonal Center, Inc.; Mhatre's biographical information; international outreach of BDIS; BDIS's corporate culture; Shoor's biographical information; history of flow cytometry; Bach's biographical information; clinical use of FACS for diagnosis, especially of cancer and AIDS; and description of the operations of a FACStar Plus machine. Visual documentation included: Demonstration of the use of a FACS machine in a clinical setting; close-up of computer monitor displaying data generated by a FACScan machine; tour of FACS manufacturing facilities; process of analysis of a cell sample by a FACStar Plus; and close-up of interior and exterior of a FACStar Plus.

Interviews Transcript, pp 1-46, of videotape recording, 3 hours.

Interviews Video Recordings of Interviews: Total Recording Time: 3 hours

Note:
- Original Masters: 7 Beta videotapes
- Preservation Masters: 7 Motion jpeg 2000 and 7 mpeg digital files
- Dubbing Masters: 3 U-matic videotapes
- Reference Copies: 2 VHS videotapes, 3 Windows Media Video and 3 Real Media digital files

Interviews **Session 2: February 1, 1991**

Interviews Recorded at Stanford University, Palo Alto, California, featured the Herzenbergs, Krasnow, Montano, Moore, Nozaki, Parks, Stovel, Sweet, and Veizades discussing the development of the FACS machine at Stanford, history of its improvements, and current research uses; c. 1955-1991, including: Description of the activities at the Shared FACS Facility; explanation of the laser system and electronics of the FACS II; description of the functions of the FACStar Plus and FACScan machines; current research applications of cell sorting technology in the Stanford Department of Genetics, particularly in AIDS research; *Drosophila* whole animal cell sorting project; the Herzenbergs' biographical information, including experiences at the Pasteur Institute; discovery of monoclonal antibodies and their application for cell sorting; experiments using glutathione

as a treatment for AIDS patients; atmosphere in the Herzenberg laboratory; history of the engineering design and construction of FACS I; adaptation of ink jet printing technology for cell sorting; current engineering modifications to FACS technology; history of the collaboration between BD and Stanford; challenges of manufacturing early commercial sorters; success of FACS I and demand for the machines by the biomedical community; development of electronics for FACS machines; early computing capabilities; and development of computer programs for subsequent generations of FACS machines. Visual documentation included: Visual tour of the offices of the Shared FACS Facility; close-ups of the FACS II machine, particularly the laser system; close-up of the FACStar Plus and FACScan machines; computer graphics generated from cell analysis on a monitor; close-up of the advanced pattern sorting FACS prototype; views of students working in the Herzenberg laboratory; photographs of *Drosophila* embryo cells; photograph of cell stream forming into droplets; molds for making valves and connector for the early FACS machine; FACS I valve box; and photos of associates of the Herzenberg laboratory.

Interviews

Transcript, pp 1-82, of videotape recording, 4 hours.

Interviews

Video Recordings of Interviews: Total Recording Time: 4 hours

Note:

- Original Masters: 11 Beta videotapes
- Preservation Masters: 11 Motion jpeg 2000 and 11 mpeg digital files
- Dubbing Masters: 4 U-matic videotapes
- Reference Copies: 2 VHS videotapes, 4 Windows Media Video and 4 Real Media digital files

Interviews

Session 3: April 19, 1991

Interviews

Was recorded at the National Museum of Health and Medicine of the Armed Forces Institute of Pathology, Washington, D.C. Leonard Herzenberg discusses the development of the FACS II and compares it with later models, as well as the importance of FACS machines for the research and diagnosis of AIDS, c. 1965-1991, including: Principle of fluorescence activated cell sorting; description of the FACS II; importance of sorting living cells; history of FACS I development; NIH funding for the project; role of BD in developing and producing commercial machines; AIDS research; and use of FACS for AIDS diagnosis. Visual documentation included: Schematic diagram illustrating the principles of cell sorting; FACS II machine and associated electronics; and a visual tour of AIDS exhibit.

Interviews

Transcript, pp 1-20, of videotape recording, 2 hours.

Interviews

Video Recordings of Interviews: Total Recording Time: 2 hours

Note:

- Original Masters: 4 Beta videotapes
- Preservation Masters: 4 Motion jpeg 2000 and 4 mpeg digital files
- Dubbing Masters: 2 U-matic videotapes

- Reference Copies: 1 VHS videotapes, 2 Windows Media Video and 2 Real Media digital files

Interviews **Session 4: June 28, 1991**

Interviews Was recorded at Brown University. Fulwyler and Van Dilla discussed their roles in the development of early cell sorting instrumentation at Los Alamos National Laboratory. Rotman recounted applications of the early instrumentation for biomedical research, c. 1950-1991, including: History of Rotman's acquisition of the Los Alamos prototype cell sorter for Brown University; description of the instrument's features; Rotman's early applications of the instrument; description of the early electronics for data analysis; history of the instrument's development at Los Alamos; adaptation of Coulter counter technology for cell sorting; scientific uses of the instrument at Los Alamos; addition of fluorescent staining of cells for sorting; use of FACS machines for determining cellular DNA content; participants' biographical information; atmosphere in the Biology Division of Los Alamos in the 1960s; differences in research styles in the corporate and academic sectors; the impact of cell sorting for biomedical research; Human Genome Project; and research prospects in biology. Visual documentation included: Close-up of the prototype cell sorter's flow chamber, droplet formation and reflection mechanism, photomultiplier, and control panel; and close-up of the sorter's early electronics, including the oscilloscope, analyzer, counter, and power supply boxes.

Interviews Transcript, pp 1-53, of videotape recording, 3 hours.

Interviews Video Recordings of Interviews: Total Recording Time: 3 hours

Note:
- Original Masters: 9 Beta videotapes
- Preservation Masters: 9 Motion jpeg 2000 and 9 mpeg digital files
- Dubbing Masters: 3 U-matic videotapes
- Reference Copies: 2 VHS videotapes, 3 Windows Media Video and 3 Real Media digital files

Interviews Supplementary Materials: April 14 and 16, 1992

Interviews Consists of B Roll and B Roll Narration videotapes and the film *Inventing the Cell Sorter*

Interviews No Transcript of videotape recordings, 1.5 hours.

Interviews Supplementary Materials: Total Recording Time: 1.5 hours

Note:
- Original Masters: 2 U-matic videotapes and 1 1" videotape
- Preservation Masters: 2 Motion jpeg 2000 and 2 mpeg digital files of B Roll tapes

- Dubbing Masters: None
- Reference Copies: 2 VHS videotapes, 2 Windows Media Video and 2 Real Media digital files of B Roll tapes