

Preface

The science of computing has come a long way since the late 1930s, when John Vincent Atanasoff and Clifford Berry began work on the first electronic digital computer. One marvels to see how the science has advanced from the days of Charles Babbage, who developed the Difference Engine in the 1820s, and, later proposed the Analytical Engine. Computer science was and continues to be an intriguing field filled with interesting stories, colorful personalities, and incredible innovations.

Ever since their invention, computers have had a profound impact on society and the ways in which humans conduct business and financial matters, fight wars and maintain peace, provide goods and services, predict events (e.g., earthquakes, the weather, global warming), monitor security and safety, and a host of other applications too numerous to mention. Plus, the personal computer revolution, beginning in the 1980s, has brought computers into many homes and schools. This has helped students find new ways to prepare reports, conduct research, and study using computerized methods. In the new millennium, the role that computers play in society continues to grow.

The World of Computer Science

In preparing this encyclopedia, I came across references to the early work on the IBM System/360 series of computers, which featured capacities of 65,000 to 16 million bytes (4 byte-words) of main storage and disk storage of several million to tens or hundreds of million bytes. At the same time, I opened the Sunday paper in February of 2002 and scanned the ads for personal computers, announcing memories of several hundred million bytes and disk storage of gigabytes. The cost of the 360 series ranged from fifty to several hundred thousand dollars to more than a million. Prices for the computers advertised in my Sunday paper ranged from several hundred dollars to a few thousand. The IBM 360 series was released in 1964. If a similar breakthrough occurred in education or automobile manufacturing (a factor of 1000, on the conservative side), a year in college would cost \$20, as would a good model car! This, of course, is not the case.

However, computer hardware is not the entire story. Machines all need software, operating systems, applications software, and the like. While a person was hard pressed to get a line drawing or a bar chart on the screen 25 years ago, someone today has a choice of presentation software (slides or projections of the computer screen), desktop publishing, spreadsheets, and the like, much of which comes bundled with the system.

In fact, today one can purchase, for a few thousand dollars, more equipment and software than the Department of Information Science and



Telecommunications at my school (the University of Pittsburgh) or, for that matter, the entire university, could buy, when I first arrived in 1974. This is, indeed, an extraordinary era to have been a part of and witnessed. However, this does not happen in a vacuum. In this encyclopedia we aim to detail the people, activities, products, and growth of knowledge that have helped computer science evolve into what it is today.

Volume Breakdown

The organization of this encyclopedia reflects the history and application of the field. Our first volume in this series is dedicated to the history of computing. Its subtitle is *Foundations: Ideas and People*. The second volume describes *Software and Hardware*, while the third addresses *Social Applications*. The fourth is appropriately subtitled the *Electronic Universe* as it looks at such developments and inventions as the Internet, ubiquitous computing (embedded computing), and miniaturization.

While the intent is to give an exhaustive view of the field, no encyclopedia of this size, or, for that matter, ten times its size, could provide a complete rendering of the developments, events, people, and technology involved. Hence, the four volumes provide a representative selection of the people, places, and events involved. The encyclopedia was developed from a U.S. point of view, but we trust that the articles herein are not intentionally biased and, hopefully, do justice to innovations and contributions from elsewhere in the world. A brief look at each volume of the encyclopedia follows.

Volume 1

Volume I discusses the foundations of computer science, including computing history and some important innovators. Among the people are American inventor Herman Hollerith (1860–1929), the designer of punched card and punched card equipment; English mathematician Charles Babbage (1791–1871), the inventor of the Difference Engine and the proposed Analytical Engine, a precursor of the stored program computer; English noblewoman Ada Byron King, the Countess of Lovelace (1815–1852), the first “computer programmer”; American executive Thomas J. Watson Sr. (1874–1956), early chief of the IBM Corporation; and American mathematician Grace Hopper (1906–1992), who helped in the development of COBOL (COmmon Business Oriented Language) and developed one of its predecessors, FLOW-MATIC, and is the person who allegedly coined the term “computer bug.”

Within Volume 1, various groups and organizations are discussed. These include the Association for Computing Machinery (ACM), which brings together people from around the globe to exchange ideas and advance computer science; the Institute of Electrical and Electronic Engineers (IEEE), which serves as the world’s largest technical professional association, with more than 350,000 members; and the IBM Corporation, Apple Computer Inc., and the Microsoft Corporation, which all contributed to the start of the personal computer (PC) revolution. Among the more general articles the reader will find those concerning topics such as early pioneers, featuring primarily American and European scientists and their work; language generations, focusing on the evolution of computer languages; and computer generations, discussing early machines such as the ENIAC (Electronic

*Explore further in Hollerith, Herman; Babbage, Charles; Lovelace, Ada Byron King, Countess of; Watson, Thomas J., Sr; and Hopper, Grace.

*Explore further in Association for Computing Machinery; Institute of Electrical and Electronic Engineers (IEEE); IBM Corporation; Apple Computer, Inc.; Microsoft Corporation; Early Pioneers; Generations, Languages; and Generations, Computers.

Numerical Integrator and Computer) and the EDVAC (Electronic Discrete Variable Automatic Computer).

Finally, other articles of general interest in Volume 1 concern the history and workings of supercomputers; the development of the mouse; the question of computer security; the beginnings of the Internet; and the basics of digital and analog computing. The government's role is explained in articles on the U.S. Census Bureau and funding research projects. In addition, mathematical tools such as the binary number system and the slide rule as well as innovations such as France's Minitel are also featured.

Volume 2

Volume 2 describes software and hardware. Articles cover topics from system analysis and design, which is the cornerstone of building a system, to operating systems, compilers, and parallel processing, which discuss some of the technical aspects of computing. Telecommunication subjects range from network design to wireless technology to ATM transmission, while application-oriented articles include pattern recognition, personal digital assistants (PDAs), and computer music. Essays concerning software products include object-oriented languages, client/server technology, invasive programs, and programming.

Among the people featured in Volume 2 are John Bardeen (1908–1991), Walter H. Brattain (1902–1987), and William B. Shockley (1910–1989), inventors of the transistor; English mathematician George Boole (1815–1864), developer of Boolean logic; and Alexander Graham Bell (1847–1922), inventor of the telephone. Rounding out Volume 2 are the technical aspects of hardware-related topics, including coding techniques, digital logic design, and cellular technology.

Volume 3

In Volume 3, the emphasis is on social applications. From fashion design to meteorology, the use of computers impacts our everyday lives. For example, computer technology has greatly influenced the study of biology, molecular biology, physics, and mathematics, not to mention the large role it plays in air traffic management and aircraft flight control, ATM machines and magnetic stripe cards for shopping and business. Businesses, large and small, have significantly benefited from applications that track product growth, costs, and the way products are managed. Volume 3 essays also explore the computer's role in medical image analysis and legal systems, while our use of computers in everyday life and our means of interacting with them are addressed in subjects such as library applications and speech recognition.

Volume 3 addresses our aesthetic and intellectual pursuits in areas such as composing music, playing chess, and designing buildings. Yet the advancements of computer sciences go much further as described in articles about agriculture, geographic information systems, and astronomy. Among the people featured in the volume are American inventor Al Gross (1918–2001), the “father of wireless”; Hungarian mathematician Rózsa Péter (1905–1977), promoter of the study of recursive functions; and American author Isaac Asimov (1920–1992), famed science fiction writer who wrote extensively about robots.

*Explore further in Supercomputers; Mouse; Security; Internet; Digital Computing; Analog Computing; Census Bureau; Government Funding; Research; Binary Number System; Slide Rule; Minitel.

*Explore further in System Analysis; Systems Design; Operating Systems; Compilers; Parallel Processing; Network Design; Wireless Technology; ATM Transmission; Pattern Recognition; Personal Digital Assistants; Music, Computer; Object-Oriented Languages; Client/Server Systems; Invasive Programs; and Programming.

*Explore further in Bardeen, John, Brattain, Walter H., and Shockley, William B.; Boole, George; Boolean Algebra; Bell, Alexander Graham; Coding Techniques; Codes; Digital Logic Design; and Cellular Technology.

*Explore further in Fashion Design; Weather Forecasting; Biology; Molecular Biology; Physics; Mathematics; Aircraft Traffic Management; Aircraft Flight Control; ATM Machines; Magnetic Stripe Cards; Project Management; Economic Modeling; Process Control; Productivity Software; Integrated Software; Image Analysis; Medicine; Legal Systems; Library Applications; Speech Recognition.

*Explore further in Music Composition; Chess Playing; Architecture; Agriculture; Geographic Information Systems; Astronomy; Gross, Alfred J.; Péter, Rózsa; Asimov, Isaac.

*Explore further in Internet: History; Internet: Applications; Internet: Backbone; Molecular Computing; Artificial Life; Mobile Computing; Cryptography; E-banking; E-books; E-commerce; E-journals and E-publishing; Information Access; Information Overload; Ethics; Copyright; and Patents.

*Explore further in Photography; Art; Cybercafe; Social Impact; Data Mining; Data Warehousing; Java Applets; JavaScript; Agents; Visual Basic.

*Explore further in Marconi, Guglielmo; Shannon, Claude E.; Glushkov, Victor M.

*Explore further in Zuse, Konrad.

*Explore further in Data Processing; Nanocomputing; Mainframes; E-mail; Abacus.

Volume 4

Volume 4 delves into our interconnected, networked society. The Internet is explored in detail, including its history, applications, and backbone. Molecular computing and artificial life are discussed, as are mobile computing and encryption technology. The reader will find articles on electronic banking, books, commerce, publishing, as well as information access and overload. Ethical matters pertaining to the electronic universe are also addressed.

Volume 4 extends our aesthetic interest with articles on photography and the use of computers in art. Readers will learn more about how cybercafes keep friends and family connected as well as the type of social impact that computers have had on society. Data gathering, storage, and retrieval are investigated in topics such as data mining and data warehousing. Similarly, Java applets, JavaScript, agents, and Visual Basic are featured.

Among the people highlighted in Volume 4 are Italian physicist Guglielmo Marconi (1874–1937), inventor of wireless communications; American engineer Claude E. Shannon (1916–2001), a pioneer of information theory; and Soviet mathematician Victor M. Glushkov (1923–1982), who advanced the science of cybernetics.

The Many Facets of Computer Science

Computer science has many interesting stories, many of which are told in this volume. Among them are the battle between John Atanasoff and John Mauchley and J. Presper Eckert Jr. over the patent to the electronic digital computer and regenerative memory, symbolized and embodied in the lawsuits between Sperry-Rand (Mauchley-Eckert) and Honeywell (Atanasoff) and Sperry-Rand (Mauchley-Eckert) and CDC (Atanasoff). The lawsuits are not covered here, but the principal actors are. And there is Thomas J. Watson's prediction, possibly apocryphal, of the need ("demand") for 50 computers worldwide! Plus, Ada Byron King, Countess of Lovelace, became famous for a reason other than being British poet Lord George Gordon Byron's daughter. And German inventor Konrad Zuse (1910–1995) saw his computers destroyed by the Allies during World War II, while Soviet mathematician Victor M. Glushkov (1923–1982) had an institute named after him and his work.

Scientific visualization is now a topic of interest, while data processing is passé. Nanocomputing has become a possibility, while mainframes are still in use and e-mail is commonplace in many parts of the world. It has been a great half-century or so (60 some years) for a fledgling field that began, possibly, with the Abacus!

Organization of the Material

Computer Sciences contains 286 entries that were newly commissioned for this work. More than 125 people contributed to this set, some from academia, some from industry, some independent consultants. Many contributors are from the United States, but other countries are represented including Australia, Canada, Great Britain, and Germany. In many cases, our contributors have written extensively on their subjects before, either in books or journal articles. Some even maintain their own web sites providing further information on their research topics.

Most entries in this set contain illustrations, either photos, graphs, charts, or tables. Many feature sidebars that enhance the topic at hand or give a glimpse into a topic of related interest. The entries—geared to high school students and general readers—include glossary definitions of unfamiliar terms to help the reader understand complex topics. These words are highlighted in the text and defined in the margins. In addition, each entry includes a bibliography of sources of further information as well as a list of related entries in the encyclopedia.

Additional resources are available in the set's front and back matter. These include a timeline on significant events in computing history, a timeline on significant dates in the history of programming and markup and scripting languages, and a glossary. An index is included in each volume—Volume 4 contains a cumulative index covering the entire *Computer Sciences* encyclopedia.

Acknowledgments and Thanks

We would like to thank Elizabeth Des Chenes and H el ene Potter, who made the project possible; Cindy Clendenon; and, especially, Kathleen Edgar, without whose work this would not have been possible. Also thanks to Stephen Murray for compiling the glossary. And, I personally would like to thank the project's two other editors, Ida M. Flynn and Ann McIver McHoes, for their dedicated work in getting these volumes out. And finally, thanks to our many contributors. They provided "many voices," and we hope you enjoy listening to them.

Roger R. Flynn
Editor in Chief

Contributors

- Tom Abel
Penn State University, University Park, PA
- Martyn Amos
University of Liverpool, United Kingdom
- Richard Archer
Pittsburgh, PA
- Pamela Willwerth Aue
Royal Oak, MI
- Nancy J. Becker
St. John's University, New York
- Mark Bedau
Reed College, Portland, OR
- Pierfrancesco Bellini
University of Florence, Italy
- Gary H. Bernstein
University of Notre Dame, Notre Dame, IN
- Anne Bissonnette
Kent State University Museum, Kent, OH
- Kevin W. Bowyer
University of Notre Dame, Notre Dame, IN
- Stefan Brass
University of Giessen, Germany
- Barbara Britton
Windsor Public Library, Windsor, Ontario, Canada
- Kimberly Mann Bruch
San Diego Supercomputer Center, University of California, San Diego
- Ivan Bruno
University of Florence, Italy
- Dennis R. Buckmaster
Pennsylvania State University, University Park, PA
- Dan Burk
University of Minnesota, Minneapolis, MN
- Guoray Cai
Pennsylvania State University, University Park, PA
- Shirley Campbell
University of Pittsburgh, Pittsburgh, PA
- Siddharth Chandra
University of Pittsburgh, Pittsburgh, PA
- J. Alex Chediak
University of California, Berkeley, CA
- Kara K. Choquette
Xerox Corporation
- John Cosgrove
Cosgrove Communications, Pittsburgh, PA
- Cheryl L. Cramer
Digimarc Corporation, Tualatin, OR
- Anthony Debons
University of Pittsburgh, Pittsburgh, PA
- Salvatore Domenick Desiano
NASA Ames Research Center (QSS Group, Inc.)
- Ken Doerbecker
Perfection Services, Inc.; WeirNet LLC; and FreeAir Networks, Inc.
- Judi Ellis
KPMG, LLP, Pittsburgh, PA
- Karen E. Esch
Karen Esch Associates, Pittsburgh, PA
- Ming Fan
University of Notre Dame, Notre Dame, IN
- Jim Fike
Ohio University, Athens, OH
- Ida M. Flynn
University of Pittsburgh, Pittsburgh, PA
- Roger R. Flynn
University of Pittsburgh, Pittsburgh, PA
- H. Bruce Franklin
Rutgers University, Newark, NJ
- Thomas J. Froehlich
Kent State University, Kent, OH
- Chuck Gaidica
WDIV-TV, Detroit, MI
- G. Christopher Hall
PricewaterhouseCoopers
- Gary Hanson
Kent State University, Kent, OH
- Karen Hartman
James Monroe Center Library, Mary Washington College, Fredericksburg, VA
- Melissa J. Harvey
Carnegie Mellon University, Pittsburgh, PA
- Albert D. Helfrick
Embry-Riddle Aeronautical University, Daytona Beach, FL
- Stephen Hughes
University of Pittsburgh, Pittsburgh, PA
- Bruce Jacob
University of Maryland, College Park, MD
- Radhika Jain
Georgia State University, Atlanta, GA
- Wesley Jamison
University of Pittsburgh at Greensburg
- Sid Karin
San Diego Supercomputer Center, University of California, San Diego
- Declan P. Kelly
Philips Research, The Netherlands
- Betty Kirke
New York, NY
- Mikko Kovalainen
University of Jyväskylä, Finland
- Paul R. Kraus
Pittsburgh, PA
- Prashant Krishnamurthy
University of Pittsburgh, Pittsburgh, PA
- Marina Krol
Mount Sinai School of Medicine, New York, NY
- Susan Landau
Sun Microsystems Inc., Mountain View, CA
- Nicholas C. Laudato
University of Pittsburgh, Pittsburgh, Pennsylvania

- George Lawton
Eutopian Enterprises
- Cynthia Tumilty Lazzaro
*Pinnacle Training Corp.,
Stoneham, MA*
- Joseph J. Lazzaro
*Massachusetts Commission for the
Blind, Boston, MA*
- John Leaney
*University of Technology, Sydney,
Australia*
- Robert Lembersky
Ann Taylor, Inc., New York, NY
- Terri L. Lenox
*Westminster College, New
Wilmington, PA*
- Joyce H-S Li
*University of Pittsburgh,
Pittsburgh, PA*
- Michael R. Macedonia
USA STRICOM, Orlando, FL
- Dirk E. Mahling
*University of Pittsburgh,
Pittsburgh, PA*
- Cynthia J. Martincic
St. Vincent College, Latrobe, PA
- Michael J. McCarthy
*Carnegie Mellon University,
Pittsburgh, PA*
- Ann McIver McHoes
Carlow College, Pittsburgh PA
- Genevieve McHoes
*University of Maryland, College
Park, MD*
- John McHugh
*CERT™ Coordination Center,
Software Engineering Institute,
Carnegie Mellon University,
Pittsburgh, PA*
- Donald M. McIver
*Northrop Grumman Corporation,
Baltimore, MD*
- Maurice McIver
*Integrated Databases, Inc.,
Honolulu, HI*
- William J. McIver, Jr.
*University at Albany, State
University of New York*
- Trevor T. Moores
University of Nevada, Las Vegas
- Christopher Morgan
*Association for Computing
Machinery, New York, NY*
- Bertha Kugelman Morimoto
*University of Pittsburgh,
Pittsburgh, PA*
- Tracy Mullen
NEC Research Inc., Princeton, NJ
- Paul Munro
*University of Pittsburgh,
Pittsburgh, PA*
- Stephen Murray
*University of Technology, Sydney,
Australia*
- Carey Nachenberg
Symantec Corporation
- John Nau
*Xceed Consulting, Inc., Pittsburgh,
PA*
- Paolo Nesi
University of Florence, Italy
- Kai A. Olsen
*Molde College and University of
Bergen, Norway*
- Ipek Özkaya
*Carnegie Mellon University,
Pittsburgh, PA*
- Bob Patterson
Perfection Services, Inc.
- Robert R. Perkoski
*University of Pittsburgh,
Pittsburgh, PA*
- Thomas A. Pollack
*Duquesne University, Pittsburgh,
PA*
- Guylaine M. Pollock
*IEEE Computer Society; Sandia
National Laboratories,
Albuquerque, NM*
- Wolfgang Porod
*University of Notre Dame, Notre
Dame, IN*
- Anwer H. Puthawala
*Park Avenue Associates in
Radiology, P.C., Binghamton, NY*
- Mary McIver Puthawala
Binghamton, NY
- Sudha Ram
University of Arizona, Tucson, AZ
- Edie M. Rasmussen
*University of Pittsburgh,
Pittsburgh, PA*
- Robert D. Regan
Consultant, Pittsburgh, PA
- Allen Renear
*University of Illinois, Urbana-
Champaign*
- Sarah K. Rich
*Pennsylvania State University,
University Park, PA*
- Mike Robinson
*Sageforce Ltd., Kingston on
Thames, Surrey, United Kingdom*
- Elke A. Rudensteiner
*Worcester Polytechnic Institute,
Worcester, MA*
- Frank R. Rusch
*University of Illinois at Urbana-
Champaign*
- William Sherman
*National Center for
Supercomputing Applications,
University of Illinois at Urbana-
Champaign*
- Marc Silverman
*University of Pittsburgh,
Pittsburgh, PA*
- Munindar P. Singh
*North Carolina State University,
Raleigh, NC*
- Cindy Smith
*PricewaterhouseCoopers, Pittsburgh,
PA*
- Barry Smyth
*Smart Media Institute, University
College, Dublin, Ireland*
- Amanda Spink
*Pennsylvania State University,
University Park, PA*
- Michael B. Spring
*University of Pittsburgh,
Pittsburgh, PA*
- Savitha Srinivasan
*IBM Almaden Research Center,
San Jose, CA*
- Igor Tarnopolsky
*Westchester County Department
of Laboratories and Research,
Valhalla, NY*
- George A. Tarnow
*Georgetown University,
Washington, DC*
- Lucy A. Tedd
*University of Wales, Aberystwyth,
Wales, United Kingdom*
- Umesh Thakkar
*National Center for
Supercomputing Applications,
University of Illinois at Urbana-
Champaign*
- Richard A. Thompson
*University of Pittsburgh,
Pittsburgh, PA*
- James E. Tomayko
*Carnegie Mellon University,
Pittsburgh, PA*
- Christinger Tomer
*University of Pittsburgh,
Pittsburgh, PA*
- Upkar Varshney
*Georgia State University, Atlanta,
GA*
- Jonathan Vos Post
Webmaster <<http://magicdragon.com>>

Tom Wall

Duke University, Durham, NC

Brett A. Warneke

*University of California, Berkeley,
CA*

Patricia S. Wehman

*University of Pittsburgh,
Pittsburgh, PA*

Isaac Weiss

*University of Maryland, College
Park, MD*

Martin B. Weiss

*University of Pittsburgh,
Pittsburgh, PA*

Jeffrey C. Wingard

Leesburg, VA

Victor L. Winter

University of Nebraska at Omaha

Charles R. Woratschek

*Robert Morris University, Moon
Township, PA*

Peter Y. Wu

*University of Pittsburgh,
Pittsburgh, PA*

William J. Yurcik

*Illinois State University,
Normal, IL*

Gregg R. Zegarelli

Zegarelli Law Group, P.C.

- vs. personal computers, 125D126, 134
- and *priesthood* of computers, 65
- programming languages, 78
- size and cost reduction, 125, 126
- telecommunications, 191
- time-sharing, 126
- Manchester Mark I computer, 56, 61D62, 198
- Manipulation robotics technology, 171
- MANs (Metropolitan area networks), 156
 - defined, 157
- Manufacturing
 - mathematics of, 26
 - minicomputers for, 140
 - robots for, 170, 171D172
 - simulator applications, 180
 - standardization, 97D99
- Mario Bros. game, 69
- Mark I computer. *See* Harvard Mark I computer; Manchester Mark I computer
- Mark II computer. *See* Harvard Mark II computer
- Marker computers, 27
- Marketing vs. privacy, 167D168
- Mary Poppins*, 13
- Massachusetts Institute of Technology. *See* MIT
- Massively parallel architecture, 162
- MasterCard, SET, 43
- Mathematicians
 - Babbage, Charles, 24D26, 25, 80, 123D124
 - Leibnitz, Gottfried Wilhelm von, 18, 165
 - Lovelace, Ada Byron King, Countess of, 7, 18, 26, 80, 122D124, 122, 149
 - Napier, John, 2, 150, 182
 - Newton, Isaac, 3, 25
 - Pascal, Blaise, 41D42, 164D166, 165
- Mathematics
 - binomial theorem, 165
 - calculus, 3D5, 132, 165
 - cycloids, 165
 - Euclidean geometry, 165
 - impact of Inquisition on, 165
 - knowledge representation, 18
 - logarithms, 2, 25, 150, 182
 - of manufacturing processes, 26
 - modeling, 180
 - Napier's bones, 150
 - trigonometry, 3
 - Turing Machine as tool, 199D200
 - See also* Binary number system; Calculating devices
- Mathews, Max, 149
- Mauchly, John W., 21, 32, 59
 - collaboration with John Atanasoff, 61
 - ENIAC project, 42, 55, 60D61, 71, 72
 - UNIVAC project, 72, 188
- Maxis
 - SimCity game, 70
 - SimHealth, 70
 - SimRefinery, 70
- MaxwellWorld, 205
- McCarthy, John, 21
- McCormick, Ernest J., 64D65
- Mechanical computers, 4D5, 41D42, 41, 131
 - See also* Analytical Engine; Difference Engine
- Medical robotics, 170
- Medical systems
 - health care policy simulations, 70
 - health statistics tracking, 32
 - telemedicine, 113
- Medium-scale integrated circuits. *See* MSI
- MEDLARS information system, 93
- MEDLINE information systems, 93
- Megabytes, defined, 129
- Melissa worm, 208
- Meltzer, Marlyn Wecoff, 63
- Memex device
 - defined, 59
 - invention, 58D59, 87
- Memory, 128D131
 - ABC computer, 53
 - cell storage, 131
 - CMOS, 130
 - of Colossus computer, 54
 - core, 57, 82
 - CRT-based, 56, 62
 - Harvard Mark I computer, 51D52
 - increasing size, 130
 - for minicomputers, 141, 142
 - protection hardware, 174D175
 - ROM, 129D130
 - synonyms, 128
 - virtual, 128, 131
 - Z machines, 52D53
 - See also* CMOS; RAM (random access memory)
- Memory extender. *See* Memex device
- Menabrea, Luigi Federico, 123
- Menu bars, 215, 216
- Menu-based systems, 111
- Menu labels, 215, 216
- Mercury man-in-space program, 153
- Merwin, Richard E., Scholarship, 104
- Mesh topology, 155
- Metasearch sites, 219
- Metropolitan area networks. *See* MANs
- MGM (Metro-Goldwyn-Mayer), animated films by, 13
- Michie, Donald, Alan Turing and, 198
- Mickey Mouse, 11, 12
- Micro Instrumentation and Telemetry Systems. *See* MITS
- Microchips/microprocessors, 131D134, 133
 - 6502 MOS Technologies, 15
 - Advanced Micro Devices, 107
 - defined, 89
 - F8, 68
 - for fourth-generation computers, 74D75
 - government research grants, 81
 - IBM, 137
 - Motorola, 16, 107
 - optical, 134
 - for RAM, 129
 - for ROM, 129D130
 - silicon chips, 74
 - size reduction, 107, 108D109
 - SLT, 89D90
 - Texas Instruments, 107
 - treatment processes, 105D106
 - See also* Intel microprocessors
- Microcomputers, 134D137
 - ergonomic designs, 65
 - hardware limitations, 136
 - history, 134D135
 - by IBM, 135D136, 136
 - operating systems, 136
 - origin of term, 135
 - programming, 135
 - RAM requirements, 136
 - size reductions, 136
 - space applications, 135, 151
 - for telecommuting, 159
 - video games for, 68
- Micromarketing
 - defined, 167
 - vs. privacy, 167D168
- Micropayments, 44
- Microprose, Transport Tycoon game, 70
- Microsoft Bookshelf, 137

- Microsoft Corporation, **137D139**
 agreement with Apple, 17, 138
 anti-trust suits, 138D139
 beginnings, 137
 Bill Gates, 137, 138
 conflicts with IBM, 138
 corporate headquarters, 139
 free browsers, 45
 intellectual property rights, 91
 software development, 137
 sued by Apple, 138
 X-Cube, 15
See also Gates, Bill
- Microsoft Disk Operating System.
See MS-DOS
- Microsoft Excel, 137
- Microsoft Internet Explorer, 14, 138, 219
- Microsoft Office, 114, 137, 138
- Microsoft Outlook, 158
- Microsoft PowerPoint, 137, 160
- Microsoft Publisher, 157
- Microsoft VBA programming languages, 208
- Microsoft Windows, 137D138
 free browsers with, 45, 138
 interfaces, 217
 keyboard locales, 121
 Windows 95, 138, 217
 Windows 98, 138, 217
 Windows 2000, 138, 217
 Windows NT, 138, 217
 Windows XP, 138
- Microsoft Word, 137, 157
- MIDI (Musical Instrument Digital Interface), 149D150
- Midway, Gunfight game, 68
- Military/warfare
 ballistics computations, 50, 55, 59, 71, 202
 code breaking, 53D55, 59, 71, 198
 computer applications, 4, 58
 ergonomically designed aircraft, 64
 punched card applications, 186D187
 robotics technologies, 170
 video games and, 67, 68, 70
- Millisecond, defined, 55
- Mindspring/Earthlink, spam filters, 49
- Minicomputers, **139D142**, 140
 applications, 140, 141
 batch processing, 141
 compilers, 141
 CRTs, 141
 defined, 135
 distinguished from personal computers, 141
 ICs for, 141
 I/O devices, 141
 memory, 141
 PDP and VAX, 13, 14, 36, 141D142
 programming languages, 141
 register numbers, 141
 rugged-ized, 140
 size and cost, 139D140
 telecommunications, 191
- Minitel network, **142D145**
 distinguished from Internet, 144D145
 history, 142D143
 i-Minitel, 144
 rates, 144
 security/privacy, 145
 service statistics, 144
 services provided, 144
 Videotex terminals, 143
- Minuteman Missile, integrated circuit technology, 153
- MIT (Massachusetts Institute of Technology)
 computer security research, 175
 flight simulators, 179
 game research, 67
 Herman Hollerith at, 83
 X-Windows, 217
- MITS (Micro Instrumentation and Telemetry Systems), Altair 8800, 137
- Mnemonic codes, 76
- Mobile robotics technology, 171
- Model animation, 10
- Model 1 computer, Bell Labs, 51
- Models
 computer, 180
 to represent artificial intelligence, 18
- Modems
 1200-baud, 69D70
 callback, 176
 FAX-modems, 158
 interconnectivity of computers, 34
 for telecommuting, 159
- Mohawk Data Sciences, first data recorder, 188
- Molecular dynamics, supercomputers to study, 184D185
- Monitor screens
 CRTs (cathode ray tubes) in, 203
 current technologies, 203
 ergonomically correct, 65
- Monopoly*, electronic version, 15
- Monroe calculator, 60
- Monte Carlo simulations, 180
- Monty Python's Flying Circus*, 10
- Moore, Ed, 27
- Moore, Gordon, 107, 108
- Moore School of Electrical Engineering, 51
 ENIAC project, 55, 60D61, 71, 72, 202
- Moore's law, 107, 108
- Morris, Robert T., 35, 37
- Morse, Samuel, 161
- Mortal Kombat game, 68
- MOS Technologies 6502 chips, 15
- Mosaic browser, 218
- Motherboard, defined, 15
- Motorola microprocessors, 16, 107
- Mouse, **145D147**
 attributes, 145
 direct manipulation systems, 112
 for disabled persons, 146
 government research grants, 81, 82
 how they work, 145D146
 invention, 21, 145
 origin of term, 145
 trackballs, 145D146
 window interfaces and, 213D214
 wireless, 147
- Movies
 MPEG format, 101
 robots in, 173
 VCRs, 164
- MPEG format, 101
- MS-DOS (Microsoft Disk Operating System), for IBM-PCs, 17, 90, 110D111, 217
- MSI (medium-scale integration), for minicomputers, 141
- Mulan*, 13
- Multics security kernel, 175
- Multimedia
 information retrieval, 92
 OAS applications, 159D160
- Multipane animation camera, 12
- Multiple Access System, 175
- Multiple Virtual Systems. *See* MVS
- Multitasking, 136
- Music, computer, **147D150**
 composition, 147, 149
 digitizing, 31
 history, 149D150
 sound synthesis and recording, 147D149
 storage devices, 164

- training hardware and software, 147, 148
- MUSIC III, 149
- Musical concerts, 149
- Musical Instrument Digital Interface. *See* MIDI
- Musical instruments
- Fairlight, 149
 - Synclavier, 149
- MVS (Multiple Virtual Systems), 126Ð127
- Myst*, 12, 15
- N**
- N- and P-type transistor regions, 195Ð196
- Namco, Ltd., Pac-Man game, 14, 15, 69
- Nanometers, defined, 161
- Nanoseconds, defined, 162
- Napier, John, 2, 150, 182
- Napier's bones, 150
- NASA (National Aeronautics and Space Administration), 151Ð154
- CMOS technology, 153
 - computer system attributes, 153
 - embedded real-time systems, 151Ð152
 - history, 151
 - impact on computer industry, 154
 - information retrieval, 93
 - integrated circuit technology, 153
 - networks, 153
 - Personal Satellite Assistant, 173
 - redundancy and backup systems, 152Ð153
- National Advisory Committee on Aeronautics (NACA), 151
- National Aeronautics and Space Administration. *See* NASA.
- National Bureau of Standards, 32, 99
- National Cash Register. *See* NCR
- National Center for Supercomputing Applications. *See* NCSA
- National Committee for Information Technology Standards. *See* NCITS
- National Crime Information Center. *See* NCIC
- National Information Infrastructure Protection Act of 1996, 36
- National Information Standards Organization. *See* NISO
- National Institute for Standards and Technology
- established, 99
 - TREC, 96
- National Library of Medicine, information retrieval research, 93
- National Science Foundation. *See* NSF
- NAVDAC (Naval Data Automation Command), Grace Hopper at, 86
- NCIC (National Crime Information Center), database privacy, 167
- NCITS (National Committee for Information Technology Standards), 100
- NCR (National Cash Register)
- mainframe computers, 125
 - T.J. Watson Sr., 88, 211
- NCSA (National Center for Supercomputing Applications), 218
- Nelson, Theodor, 87, 88
- NES (Nintendo Entertainment System), 69
- Netscape Navigator, 14, 219
- Network sniffing, 177
- Network topologies, 154Ð155
- Networked windows. *See* NeWs
- Networks, 154Ð157
- ATM transmission, 155Ð156
 - broadcast, 154
 - circuit-switched, 154
 - copper cabling for, 155
 - electromagnetic energy use, 155
 - Ethernet, 156, 222
 - fiber optics for, 155
 - frame relay, 156
 - hypertext and design, 88
 - Internet/intranets as, 157
 - LANs, 115, 128, 156Ð157, 191
 - MANs, 156
 - NASA-developed, 153
 - packet-switched, 116Ð117, 154
 - PARC contributions, 222
 - peer-to-peer vs. hierarchical, 115
 - WANs, 128, 156, 157
 - window interfaces, 217
- Neurology, supercomputers as tool, 185
- Newell, Allen, award (ACM), 21
- Newman, Lyn, 199
- Newman, Maxwell, 56, 61Ð62, 199
- NeWs (networked windows), 217
- Newton, Isaac, 3, 25
- NewtonWorld, 205
- NeXT, 16
- Nexus, 218
- 1984 Act, 34Ð35
- Nintendo
- Donkey Kong game, 69
 - Entertainment System (NES), 14, 69
 - Famicom, 14
 - GameBoy, 69
 - GameCube, 15
 - Mario Bros. game, 69
 - revenues from games, 181
 - The Ninth Bridgewater Treatise*, 26
- NISO (National Information Standards Organization), 100
- No. 1 Electronic Switching System. *See* 1E
- Nobel prizes
- for Bell Labs employees, 27
 - superconductivity research, 106
 - transistor inventors, 63, 106, 192
- No'1 (contemporary of Pascal), 166
- Norman, Donald, 111
- Notebook computers. *See* Laptop computers
- Noyce, Robert, 73, 74, 106, 107
- NPN transistors, 196
- NSF (National Science Foundation), 81
- NSFnet, 115
- N² transistors, 194Ð195
- Nuclear power, robotics and, 170
- Nynex, 28
- O**
- OAS (office automation systems), 157Ð160
- Douglas Engelbart's contributions, 87
 - electronic collaboration, 157, 158Ð159
 - electronic communication, 157, 158
 - electronic publishing, 157
 - high-tech meeting rooms, 159
 - image processing, 157, 159Ð160
 - LAN's role, 157
 - Microsoft Office, 137, 138
 - office management, 157, 160
 - Xerox Star, 111
- Object-based/object oriented-programming environments, 112Ð113
- Object-oriented languages
- Ada, 80
 - C++, 80
 - Java, 80
 - Smalltalk, 80, 216Ð217
- Occupational Health and Safety Administration. *See* OSHA
- Octal (base-8) number system