

ENCYCLOPEDIA OF 20TH-CENTURY  
**TECHNOLOGY**

Volume 1  
A-L

Colin A. Hempstead, Editor  
William E. Worthington, Jr., Associate Editor

**ROUTLEDGE**  
NEW YORK AND LONDON

**Also available as a printed book  
see title verso for ISBN details**

---

ENCYCLOPEDIA OF 20TH-CENTURY  
**TECHNOLOGY**



---

# ENCYCLOPEDIA OF 20TH-CENTURY TECHNOLOGY

Volume 1  
A-L

Colin A. Hempstead, Editor

William E. Worthington, Jr., Associate Editor

**ROUTLEDGE**  
NEW YORK AND LONDON

---

Published in 2005 by  
Routledge  
270 Madison Avenue  
New York, NY 10016  
www.routledge-ny.com

Published in Great Britain by  
Routledge  
2 Park Square  
Milton Park, Abingdon  
Oxon OX14 4RN, UK  
www.routledge.co.uk

Copyright © 2005 by Routledge

Routledge is an imprint of the Taylor & Francis Group.

This edition published in the Taylor & Francis e-Library, 2005.

“To purchase your own copy of this or any of Taylor & Francis or Routledge’s collection of thousands of eBooks please go to [www.eBookstore.tandf.co.uk](http://www.eBookstore.tandf.co.uk).”

All rights reserved. No part of this book may be reprinted or reproduced or utilized in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage and retrieval system, without permission in writing from the publisher.

**Library of Congress Cataloging-in-Publication Data**

Encyclopedia of 20th-century technology / Colin A. Hempstead, editor; William E. Worthington, associate editor.  
p. cm.

Includes bibliographical references and index.

ISBN 1-57958-386-5 (set : alk. paper)—ISBN 1-57958-463-2 (vol. 1 : alk. paper)—

ISBN 1-57958-464-0 (vol. 2 alk. paper)

1. Technology—Encyclopedias. I. Hempstead, Colin. II. Worthington, William E., 1948–  
T9.E462 2005  
603—dc22

ISBN 0-203-99699-2 Master e-book ISBN

---

# Advisers

---

**Dr. Jon Agar**, Department of History and  
Philosophy of Science, University of  
Cambridge

**Professor Janet Bainbridge**, Chief Executive,  
EPICC (European Process Industries  
Competitiveness Centre), Teesside

**Dr. Hans Joachim Braun**, Universität der  
Bundeswehr Hamburg

**Dr. Robert Bud**, Principal Curator of Science,  
Science Museum, London

**Dr. Michael Duffy**, formerly Department of  
Engineering, University of Sunderland

**Dr. Slava Gerovitch**, Dibner Institute for the  
History of Science and Technology, MIT

**Dr. Ernst Homburg**, Department of History,  
University of Maastricht

**Dr. Sally Horrocks**, Department of Economic and  
Social History, University of Leicester

**R. Douglas Hurt**, Professor and Director, Graduate  
Program in Agricultural History and Rural  
Studies, Department of History, Iowa State  
University

**Dr. Peter Morris**, Science Museum, London

**Professor John Pickstone**, Centre for the History of  
Science, Technology and Medicine, University  
of Manchester

**Keith Thrower**, former Technical Director at Racal  
Electronics, UK



---

# Contents

---

Advisers	v
List of Entries	ix
Thematic List of Entries	xv
Editor's Preface	xxi
Associate Editor's Preface	xxiii
Acknowledgments	xxv
Contributors	xxvii
Entries A through Z	1
Index	915





---

# List of Entries

---

## Volume One

- Absorbent Materials
- Activated Carbon
- Adhesives
- Agriculture and Food
- Air Conditioning
- Air Traffic Control Systems
- Aircraft Carriers
- Aircraft Design:
  - Biplane and externally braced wings
  - Streamlined monoplanes
  - Transonic
  - Supersonic and hypersonic
- Aircraft Instrumentation
- Alloys, Light and Ferrous
- Alloys, Magnetic
- Analgesics
- Anesthetics
- Angiography
- Antibacterial Chemotherapy
- Antibiotics, Developments through 1945
- Antibiotics, Use after 1945
- Artificial Insemination and *in Vitro* Fertilization
- Artificial Intelligence
- Audio Recording, Compact Disc
- Audio Recording, Electronic Methods
- Audio Recording, Mechanical
- Audio Recording, Stereophonic and Surround Sound
- Audio Recording, Tape
- Audio Recording, Wire
- Audio Systems
- Audiology, Hearing Aids
- Audiology, Implants and Surgery
- Audiology, Testing
- Automobiles
- Automobiles, Electric
- Automobiles, Hybrid
- Automobiles, Internal Combustion
  
- Batteries, Primary and Secondary
- Battleships
- Biomass Power Generation
  
- Biopolymers
- Biotechnology
- Blood Transfusion and Blood Products
- Boranes
- Breeding, Animal: Genetic Methods
- Breeding, Plant: Genetic Methods
- Bridges, Concrete
- Bridges, Long Span and Suspension
- Bridges, Steel
- Building Acoustics
- Buildings, Designs for Energy Conservation
- Buildings, Prefabricated
  
- Calculators, Electronic
- Calculators, Mechanical and Electromechanical
- Cameras, 35 mm
- Cameras, Automatic
- Cameras, Digital
- Cameras, Disposable
- Cameras, Lens Designs: Wide Angle and Zoom
- Cameras, Polaroid
- Cameras, Single Lens Reflex (SLR)
- Cancer, Chemotherapy
- Cancer, Radiation Therapy
- Cancer, Surgical Techniques
- Cardiovascular Disease, Pharmaceutical Treatment
- Cardiovascular Surgery, Pacemakers and Heart Valves
- Catamarans
- Ceramic Materials
- Changing Nature of Work
- Chemical Process Engineering
- Chemicals
- Chromatography
- Civil Aircraft, Jet Driven
- Civil Aircraft, Propeller Driven
- Civil Aircraft, Supersonic
- Cleaning: Chemicals and Vacuum Cleaners
- Clocks and Watches, Quartz
- Clocks, Atomic
- Cloning, Testing and Treatment Methods
- Coatings, Pigments, and Paints
- Color Photography

Combinatorial Chemistry  
 Communications  
 Composite Materials  
 Computer and Video Games  
 Computer Displays  
 Computer Memory, Early  
 Computer Memory, Personal Computers  
 Computer Modeling  
 Computer Networks  
 Computer Science  
 Computer-Aided Design and Manufacture  
 Computers, Analog  
 Computers, Early Digital  
 Computers, Hybrid  
 Computers, Mainframe  
 Computers, Personal  
 Computers, Supercomputers  
 Computers, Uses and Consequences  
 Computer–User Interface  
 Concrete, Reinforced  
 Concrete Shells  
 Constructed World  
 Construction Equipment  
 Contraception: Hormonal Methods and Surgery  
 Contraception: Physical and Chemical Methods  
 Control Technology, Computer-Aided  
 Control Technology, Electronic Signals  
 Cracking  
 Crop Protection, Spraying  
 Cryogenics, Applications  
 Cryogenics, Liquefaction of Gases  
 Crystals, Synthetic  
  
 Dairy Farming  
 Dams  
 Dentistry  
 Detergents  
 Diabetes Mellitus  
 Diagnostic Screening  
 Dialysis  
 Dirigibles  
 Dishwashers  
 Domestic Heating  
 Dyes  
  
 Electric Motors  
 Electrical Energy Generation and Supply, Large Scale  
 Electrical Power Distribution  
 Electricity Generation and the Environment  
 Electrocardiogram (ECG)  
 Electrochemistry  
 Electroencephalogram (EEG)  
 Electronic Communications  
 Electronics  
  
 Electrophoresis  
 Encryption and Code Breaking  
 Energy and Power  
 Engineering: Cultural, Methodological and Definitional Issues  
 Engineering: Production and Economic Growth  
 Entertainment in the Home  
 Environmental Monitoring  
 Error Checking and Correction  
 Experimental Stress Analysis  
 Explosives, Commercial  
  
 Farming, Agricultural Methods  
 Farming, Growth Promotion  
 Farming, Mechanization  
 Fax Machine  
 Feedstocks  
 Fertility, Human  
 Fertilizers  
 Fibers, Synthetic and Semi-Synthetic  
 Film and Cinema: Early Sound Films  
 Film and Cinema: High Fidelity to Surround Sound  
 Film and Cinema: Sets and Techniques  
 Film and Cinema: Wide Screen Systems  
 Fire Engineering  
 Fish Farming  
 Fission and Fusion Bombs  
 Fly-by-Wire Systems  
 Food Additives and Substitutes  
 Food Preparation and Cooking  
 Food Preservation: Cooling and Freezing  
 Food Preservation: Freeze Drying, Irradiation, and Vacuum Packing  
 Food, Processed and Fast  
 Fossil Fuel Power Stations  
 Fuel Cells  
  
 Gender and Technology  
 Gene Therapy  
 Genetic Engineering, Applications  
 Genetic Engineering, Methods  
 Genetic Screening and Testing  
 Global Positioning System (GPS)  
 Globalization  
 Green Chemistry  
 Gyrocompass and Inertial Guidance  
  
 Hall Effect Devices  
 Health  
 Hearts, Artificial  
 Helicopters  
 Hematology  
 Highways  
 Histology

- Hormone Therapy  
Hovercraft, Hydrofoils, and Hydroplanes  
Hydroelectric Power Generation
- Iconoscope  
Immunological Technology  
Implants, Joints and Stents  
Industrial Gases  
Information Theory  
Infrared Detectors  
Integrated Circuits, Design and Use  
Integrated Circuits, Fabrication  
Intensive Care and Life Support  
Internal Combustion Piston Engine  
Internet  
Iron and Steel Manufacture  
Irrigation Systems  
Isotopic Analysis
- Josephson Junction Devices
- Lasers, Applications  
Lasers in Optoelectronics  
Lasers, Theory and Operation  
Laundry Machines and Chemicals  
Light Emitting Diodes  
Lighting, Public and Private  
Lighting Techniques  
Liquid Crystals  
Loudspeakers and Earphones
- Volume Two**  
Mass Spectrometry  
Materials and Industrial Processes  
Medicine  
Methods in the History of Technology  
Microscopy, Electron Scanning  
Microscopy, Electron Transmission  
Microscopy, Optical  
Microwave Ovens  
Military versus Civil Technologies  
Missiles, Air to Air  
Missiles, Air to Surface  
Missiles, Defensive  
Missiles, Long Range and Ballistic  
Missiles, Long Range and Cruise  
Missiles, Short Range and Guided  
Missiles, Surface-to-Air and Anti-Ballistic  
Mobile (Cell) Telephones  
Motorcycles
- Nanotechnology, Materials and Applications  
Neurology
- Nitrogen Fixation  
Nuclear Fuels  
Nuclear Magnetic Resonance (NMR) and  
Magnetic Resonance Imaging (MRI)  
Nuclear Reactor Materials  
Nuclear Reactors: Fast Breeders  
Nuclear Reactors: Fusion, Early Designs  
Nuclear Reactors: Fusion, Later Designs  
Nuclear Reactors: Thermal, Graphite Moderated  
Nuclear Reactors: Thermal, Water Moderated  
Nuclear Reactors: Weapons Material  
Nuclear Waste Processing and Storage
- Oil from Coal Process  
Oil Rigs  
Ophthalmology  
Optical Amplifiers  
Optical Materials  
Optoelectronics, Dense Wavelength Division  
Multiplexing  
Optoelectronics, Frequency Changing  
Optometry  
Organ Transplantation  
Organization of Technology and Science
- Packet Switching  
Particle Accelerators: Cyclotrons, Synchrotrons,  
and Colliders  
Particle Accelerators, Linear  
Personal Stereo  
Pest Control, Biological  
Pesticides  
Photocopiers  
Photosensitive Detectors  
Plastics, Thermoplastics  
Plastics, Thermosetting  
Positron Emission Tomography (PET)  
Power Generation, Recycling  
Power Tools and Hand-Held Tools  
Presentation of Technology  
Printers  
Processors for Computers  
Prospecting, Minerals  
Psychiatry, Diagnosis and Non-Drug Treatments  
Psychiatry, Pharmaceutical Treatment
- Quantum Electronic Devices
- Radar aboard Aircraft  
Radar, Defensive Systems in World War II  
Radar, Displays  
Radar, High Frequency and High Power  
Radar, Long Range Early Warning Systems  
Radar, Origins to 1939

- Radio: AM, FM, Analog, and Digital  
 Radio, Early Transmissions  
 Radio Receivers, Coherers and Magnetic Methods  
 Radio Receivers, Crystal Detectors and Receivers  
 Radio Receivers, Early  
 Radio Receivers, Valve and Transistor Circuits  
 Radio Transmitters, Continuous Wave  
 Radio Transmitters, Early  
 Radioactive Dating  
 Radio-Frequency Electronics  
 Radionavigation  
 Rail, Diesel and Diesel Electric Locomotives  
 Rail, Electric Locomotives  
 Rail, High Speed  
 Rail, Steam Locomotives  
 Railway Mechanics  
 Rectifiers  
 Refrigeration, Absorption  
 Refrigeration, Mechanical  
 Refrigeration, Thermoelectricity  
 Reppe Chemistry  
 Research and Development in the 20th Century  
 Rocket Planes  
 Rocket Propulsion, Liquid Propellant  
 Rocket Propulsion, Solid Propellant
- Satellites, Communications  
 Satellites, Environmental Sensing  
 Semiconductors, Compound  
 Semiconductors, Crystal Growing and Purification  
 Semiconductors, Elemental  
 Semiconductors, Postband Theory  
 Semiconductors, Preband Theory  
 Ships: Bulk Carriers and Tankers  
 Skyscrapers  
 Smart and Biomimetic Materials  
 Social and Political Determinants of Technological Change  
 Software Application Programs  
 Software Engineering  
 Solar Power Generation  
 Solvents  
 Sonar  
 Space  
 Space Exploration, Fly Past  
 Space Exploration, Manned Orbiters  
 Space Exploration, Moon, Manned  
 Space Exploration, Moon, Unmanned  
 Space Exploration, Planetary Landers  
 Space Exploration, Unmanned  
 Space Launch Vehicles  
 Space Shuttle  
 Space Stations, International Space Station  
 Space Stations, Mir  
 Space Stations, Skylab
- Spectroscopy and Spectrochemistry, Visible and Ultraviolet  
 Spectroscopy, Infrared  
 Spectroscopy, Raman  
 Spectroscopy, X-ray Fluorescence  
 Sports Science and Technology  
 Sputniks  
 Strobe Flashes  
 Submarines, Military  
 Submersibles  
 Superconductivity, Applications  
 Superconductivity, Discovery  
 Surgery, Plastic and Reconstructive  
 Synthetic Foods, Mycoprotein and Hydrogenated Fats  
 Synthetic Resins  
 Synthetic Rubber  
 Systems Programs
- Tanks  
 Technology and Ethics  
 Technology and Leisure  
 Technology, Arts and Entertainment  
 Technology, Society and the Environment  
 Telecommunications  
 Telephony, Automatic Systems  
 Telephony, Digital  
 Telephony, Long Distance  
 Telescopes, Computer-controlled Mirrors  
 Telescopes, Ground  
 Telescopes, Radio  
 Telescopes, Space  
 Television, Beginning Ideas (Late 19th and Early 20th Century)  
 Television, Cable and Satellite  
 Television, Color, Electromechanical  
 Television: Color, Electronic  
 Television, Digital and High Definition Systems  
 Television, Electromechanical Systems  
 Television Recording, Disc  
 Television Recording, Tape  
 Thin Film Materials and Technology  
 Timber Engineering  
 Tissue Culturing  
 Tomography in Medicine  
 Transistors  
 Transport  
 Transport, Foodstuffs  
 Transport, Human Power  
 Travelling Wave Tubes  
 Tunnels and Tunneling  
 Turbines, Gas  
 Turbines: Gas, in Aircraft  
 Turbines: Gas, in Land Vehicles  
 Turbines, Steam

Ultracentrifuges	Warfare, Chemical
Ultrasonography in Medicine	Warfare, High Explosive Shells and Bombs
Urban Transportation	Warplanes, Bombers
	Warplanes, Fighters and Fighter Bombers
	Warplanes, Reconnaissance
Vacuum Tubes/Valves	Wind Power Generation
Vertical Transportation	World Wide Web
Vitamins, Isolation and Synthesis	Wright Flyers
Warfare	X-ray Crystallography
Warfare, Biological	X-rays in Diagnostic Medicine



---

# Thematic List of Entries

---

## **Biotechnology**

Antibacterial Chemotherapy  
Artificial Insemination and *in Vitro* Fertilization  
Biopolymers  
Biotechnology  
Breeding, Animal: Genetic Methods  
Breeding, Plant: Genetic Methods  
Cloning, Testing and Treatment Methods  
Gene Therapy  
Genetic Engineering, Methods  
Genetic Engineering, Applications  
Genetic Screening and Testing  
Tissue Culturing  
*See also* **Food and Agriculture; Health and Medicine**

## **Chemistry**

Biopolymers  
Boranes  
Chemicals  
Chemical Process Engineering  
Chromatography  
Coatings, Pigments, and Paints  
Combinatorial Chemistry  
Cracking  
Detergents  
Dyes  
Electrochemistry  
Electrophoresis  
Environmental Monitoring  
Explosives  
Feedstocks  
Green Chemistry  
Industrial Gases  
Isotopic Analysis  
Nitrogen Fixation  
Oil from Coal Process  
Radioactive Dating  
Repepe Chemistry  
Solvents  
Synthetic Resins  
Synthetic Rubber  
Warfare, Chemical

*See also* **Materials; Scientific Research/Measurement**

## **Communications**

Communications  
Electronic Communications  
Fax Machine  
Mobile (Cell) Telephones  
Radio-Frequency Electronics  
Satellites, Communications  
Telecommunications  
Telephony, Automatic Systems  
Telephony, Digital  
Telephony, Long Distance

## **Computers**

Artificial Intelligence  
Computer and Video Games  
Computer Displays  
Computer Memory, Early  
Computer Memory, Personal Computers  
Computer Modeling  
Computer Networks  
Computer Science  
Computer-Aided Design and Manufacture  
Computers, Analog  
Computers, Early Digital  
Computers, Hybrid  
Computers, Mainframe  
Computers, Personal  
Computers, Supercomputers  
Computers, Uses and Consequences  
Computer–User Interface  
Control Technology, Computer-Aided  
Control Technology, Electronic Signals  
Error Checking and Correction  
Encryption and Code Breaking  
Global Positioning System (GPS)  
Gyrocompass and Inertial Guidance  
Information Theory  
Internet  
Packet Switching



Printers  
 Processors for Computers  
 Prospecting, Minerals  
 Radionavigation  
 Software Application Programs  
 Software Engineering  
 Systems Programs  
 World Wide Web

**Construction**

Bridges, Concrete  
 Bridges, Long Span and Suspension  
 Bridges, Steel  
 Building Acoustics  
 Buildings, Designs for Energy Conservation  
 Buildings, Prefabricated  
 Concrete, Reinforced  
 Concrete Shells  
 Constructed World  
 Construction Equipment  
 Dams  
 Experimental Stress Analysis  
 Fire Engineering  
 Oil Rigs  
 Power Tools and Hand-Held Tools  
 Skyscrapers  
 Timber Engineering  
 Tunnels and Tunneling  
 Vertical Transportation

**Electronics and Electrical Engineering**

Calculators, Electronic  
 Calculators, Mechanical and Electromechanical  
 Clocks and Watches, Quartz  
 Control Technology, Electronic Signals  
 Electric Motors  
 Electronic Communications  
 Electronics  
 Fax Machine  
 Hall Effect Devices  
 Infrared Detectors  
 Integrated Circuits, Design and Use  
 Integrated Circuits, Fabrication  
 Josephson Junction Devices  
 Lasers, Theory and Operation  
 Lasers, Applications  
 Lasers in Optoelectronics  
 Light Emitting Diodes  
 Lighting, Public and Private  
 Lighting Techniques  
 Mobile (Cell) Telephones  
 Photocopiers  
 Photosensitive Detectors  
 Quantum Electronic Devices  
 Radio-Frequency Electronics

Rectifiers  
 Strobe Flashes  
 Superconductivity, Applications  
 Superconductivity, Discovery  
 Transistors  
 Vacuum Tubes/Valves  
 Travelling Wave Tubes  
*See also* **Television, Radio, Audio Recording**

**Energy and Power**

Batteries, Primary and Secondary  
 Biomass Power Generation  
 Electrical Energy Generation and Supply, Large Scale  
 Electrical Power Distribution  
 Electricity Generation and the Environment  
 Fossil Fuel Power Stations  
 Fuel Cells  
 Hydroelectric Power Generation  
 Nuclear Reactors: Fast Breeders  
 Nuclear Reactors: Fusion, Early Designs  
 Nuclear Reactors: Fusion, Later Designs  
 Nuclear Reactors: Thermal, Graphite Moderated  
 Nuclear Reactors: Thermal, Water Moderated  
 Power Generation, Recycling  
 Solar Power Generation  
 Turbines, Gas  
 Turbines, Steam  
 Turbines: Gas, in Land Vehicles  
 Wind Power Generation

**Environment**

Environmental Monitoring  
 Green Chemistry  
 Satellites, Environmental Sensing  
 Technology, Society and the Environment  
*See also* **Energy and Power**

**Film, Cinema, Photography**

Cameras, 35 mm  
 Cameras, Automatic  
 Cameras, Digital  
 Cameras, Disposable  
 Cameras, Polaroid  
 Cameras, Single Lens Reflex (SLR)  
 Cameras: Lens Designs, Wide Angle, Zoom  
 Film, Color Photography  
 Film and Cinema: Early Sound Films  
 Film and Cinema: High Fidelity to Surround Sound  
 Film and Cinema: Sets and Techniques  
 Film and Cinema: Wide Screen Systems

**Food and Agriculture**

Activated Carbon

Agriculture and Food  
 Crop Protection, Spraying  
 Dairy Farming  
 Farming, Agricultural Methods  
 Farming, Growth Promotion  
 Farming, Mechanization  
 Fertilizers  
 Fish Farming  
 Food Additives and Substitutes  
 Food Preparation and Cooking  
 Food Preservation: Cooling and Freezing  
 Food Preservation: Freeze Drying, Irradiation,  
 and Vacuum Packing  
 Food, Processed and Fast  
 Irrigation Systems  
 Nitrogen Fixation  
 Pesticides  
 Pest Control, Biological  
 Synthetic Foods, Mycoprotein and Hydrogenated  
 Fats  
 Transport, Foodstuffs

### **Health and Medicine**

Analgesics  
 Anesthetics  
 Angiography  
 Antibacterial Chemotherapy  
 Antibiotics, Developments through 1945  
 Antibiotics, Use after 1945  
 Audiology, Hearing Aids  
 Audiology, Implants and Surgery  
 Audiology, Testing  
 Blood Transfusion and Blood Products  
 Cancer, Chemotherapy  
 Cancer, Radiation Therapy  
 Cancer, Surgical Techniques  
 Cardiovascular Disease, Pharmaceutical  
 Treatment  
 Cardiovascular Surgery, Pacemakers and Heart  
 Valves  
 Contraception, Hormonal Methods and Surgery  
 Contraception, Physical and Chemical Methods  
 Dentistry  
 Diabetes Mellitus  
 Diagnostic Screening  
 Dialysis  
 Electrocardiogram (ECG)  
 Electroencephalogram (EEG)  
 Fertility, Human  
 Health  
 Hearts, Artificial  
 Hematology  
 Histology  
 Hormone Therapy  
 Immunological Technology

Implants, Joints and Stents  
 Intensive Care and Life Support  
 Medicine  
 Neurology  
 Ophthalmology  
 Optometry  
 Organ Transplantation  
 Positron Emission Tomography (PET)  
 Psychiatry, Diagnosis and Non-Drug Treatments  
 Psychiatry, Pharmaceutical Treatment  
 Surgery, Plastic and Reconstructive  
 Tomography in Medicine  
 Ultrasonography in Medicine  
 Vitamins, Isolation and Synthesis  
 X-rays in Diagnostic Medicine

### **Homes**

Air Conditioning  
 Buildings, Designs for Energy Conservation  
 Buildings, Prefabricated  
 Cleaning: Chemicals and Vacuum Cleaners  
 Dishwashers  
 Domestic Heating  
 Entertainment in the Home  
 Laundry Machines and Chemicals  
 Lighting, Public and Private  
 Microwave Ovens

### **Leisure and Entertainment**

Audio Recording  
 Audio Systems  
 Computer and Video Games  
 Loudspeakers and Earphones  
 Personal Stereo  
 Radio, Early Transmissions  
 Sports Science and Technology  
 Technology, Arts and Entertainment  
 Technology and Leisure  
 Television, Various Entries  
*See also Film, Cinema, Photography; TV, Radio,  
 Audio Recording*

### **Materials**

Absorbent Materials  
 Adhesives  
 Alloys, Light and Ferrous  
 Alloys, Magnetic  
 Ceramic Materials  
 Composite Materials  
 Crystals, Synthetic  
 Fibers, Synthetic and Semi-Synthetic  
 Iron and Steel Manufacture  
 Liquid Crystals  
 Materials and Industrial Processes  
 Nanotechnology, Materials and Applications

Nuclear Fuels  
 Nuclear Reactor Materials  
 Nuclear Waste Processing and Storage  
 Optical Materials  
 Plastics, Thermoplastics  
 Plastics, Thermosetting  
 Semiconductors, Compound  
 Semiconductors, Elemental  
 Semiconductors, Postband Theory  
 Semiconductors, Preband Theory  
 Semiconductors: Crystal Growing, Purification  
 Superconductivity, Discovery  
 Smart and Biomimetic Materials  
 Synthetic Resins  
 Synthetic Rubbers  
 Thin Film Materials and Technology  
*See also* **Chemistry**

**Scientific Research/Measurement**

Clocks, Atomic  
 Chromatography  
 Cryogenics, Applications  
 Cryogenics, Liquefaction of Gases  
 Electrophoresis  
 Isotopic Analysis  
 Mass Spectrometry  
 Microscopy, Electron (Scanning)  
 Microscopy, Electron (Transmission)  
 Microscopy, Optical  
 Nuclear Magnetic Resonance (NMR) and  
 Magnetic Resonance Imaging (MRI)  
 Particle Accelerators: Cyclotrons, Synchrotrons,  
 and Colliders  
 Particle Accelerators, Linear  
 Radioactive Dating  
 Refrigeration, Absorption  
 Refrigeration, Mechanical  
 Refrigeration, Thermoelectricity  
 Research and Development in the 20th Century  
 Spectroscopy and Spectrochemistry, Visible and  
 UV  
 Spectroscopy, Infrared  
 Spectroscopy, Raman  
 Spectroscopy, X-ray Fluorescence  
 Ultracentrifuges  
 X-ray Crystallography

**Space**

Rocket Propulsion, Liquid Propellant  
 Rocket Propulsion, Solid Propellant  
 Satellites, Communications  
 Satellites, Environmental Sensing  
 Space  
 Space Exploration, Fly Past  
 Space Exploration, Manned Orbiters

Space Exploration: Moon, Manned  
 Space Exploration: Moon, Unmanned  
 Space Exploration, Planetary Landers  
 Space Exploration, Unmanned  
 Space Launch Vehicles  
 Space Shuttle  
 Space Stations, International Space Station  
 Space Stations, Mir  
 Space Stations, Skylab  
 Sputniks  
 Telescopes, Computer-Controlled Mirrors  
 Telescopes, Ground  
 Telescopes, Radio  
 Telescopes, Space

**Thematic Overviews**

Agriculture and Food  
 Biotechnology  
 Changing Nature of Work  
 Chemicals  
 Communications  
 Computers, Uses and Consequences  
 Constructed World  
 Electronics  
 Energy and Power  
 Engineering: Cultural, Methodological and  
 Definitional Issues  
 Engineering: Production and Economic Growth  
 Gender and Technology  
 Globalization  
 Health  
 Materials and Industrial Processes  
 Medicine  
 Methods in the History of Technology  
 Military Versus Civil Technologies  
 Organization of Technology and Science  
 Presentation of Technology  
 Research and Development in the 20th Century  
 Social and Political Determinants of Technological  
 Change  
 Space  
 Technology, Arts and Entertainment  
 Technology and Ethics  
 Technology and Leisure  
 Technology, Society and the Environment  
 Telecommunications  
 Transport  
 Warfare

**Transportation**

Air Traffic Control Systems  
 Aircraft Design  
 Aircraft Instrumentation  
 Automobiles  
 Automobiles, Electric

Automobiles, Hybrid  
 Automobiles, Internal Combustion  
 Catamarans  
 Civil Aircraft, Jet Driven  
 Civil Aircraft, Propeller Driven  
 Civil Aircraft, Supersonic  
 Dirigibles  
 Fly-by-Wire Systems  
 Helicopters  
 Highways  
 Hovercraft, Hydrofoils, and Hydroplanes  
 Internal Combustion Piston Engine  
 Motorcycles  
 Rail, Diesel and Diesel Electric Locomotives  
 Rail, Electric Locomotives  
 Rail, High Speed  
 Rail, Steam Locomotives  
 Railway Mechanics  
 Rocket Planes  
 Ships: Bulk Carriers and Tankers  
 Submersibles  
 Transport  
 Transport, Foodstuffs  
 Transport, Human Power  
 Turbines: Gas, in Aircraft  
 Urban Transportation  
 Wright Flyers

#### **Television, Radio, Audio Recording**

Audio Recording, Compact Disc  
 Audio Recording, Electronic Methods  
 Audio Recording, Mechanical  
 Audio Recording, Stereophonic and Surround  
 Sound  
 Audio Recording, Tape  
 Audio Recording, Wire  
 Audio Systems  
 Iconoscope  
 Loudspeakers and Earphones  
 Personal Stereo  
 Radio Receivers, Coherers and Magnetic Methods  
 Radio Receivers, Crystal Detectors and Receivers  
 Radio Receivers, Early  
 Radio Receivers, Valve and Transistor Circuits  
 Radio Transmitters, Continuous Wave  
 Radio Transmitters, Early

Radio, Early Transmissions  
 Radio: AM, FM, Analog, and Digital  
 Television Recording, Disc  
 Television Recording, Tape  
 Television, Cable and Satellite  
 Television, Digital and High Definition Systems  
 Television, Electro-Mechanical Systems  
 Television, Beginning Ideas (Late 19th and Early  
 20th Century)  
 Television, Color, Electromechanical  
 Television: Color, Electronic  
*See also **Film and Cinema; Leisure and  
 Entertainment***

#### **Warfare**

Aircraft Carriers  
 Battleships  
 Explosives, Commercial  
 Fission and Fusion Bombs  
 Military Versus Civil Technologies  
 Missiles, Air-to-Air  
 Missiles, Air-to-Surface  
 Missiles, Defensive  
 Missiles, Long Range and Ballistic  
 Missiles, Long Range and Cruise  
 Missiles, Short Range and Guided  
 Missiles, Surface-to-Air and Anti-Ballistic  
 Nuclear Reactors: Weapons Material  
 Radar Aboard Aircraft  
 Radar, Defensive Systems in World War II  
 Radar, Displays  
 Radar, High-Frequency and High-Power  
 Radar, Long Range and Early Warning Systems  
 Radar, Origins to 1939  
 Sonar  
 Submarines, Military  
 Tanks  
 Warfare  
 Warfare, Biological  
 Warfare, Chemical  
 Warfare, High Explosive Shells and Bombs  
 Warfare, Mines and Antipersonnel Devices  
 Warplanes, Bombers  
 Warplanes, Fighters and Fighter Bombers  
 Warplanes, Reconnaissance



---

# Editor's Preface

---

All editors of encyclopedias are faced with the problem of what to include. Even if the title is agreed and the numbers of volumes and pages have been decided, the sum of possible entries could be very large. In the case of the *Encyclopedia of 20th-Century Technology*, the editor decided that in order to construct a logical and consistent set of entries it was necessary to adopt what could be described as an analytic framework. During the 20th century a plethora of manufactured articles have appeared for which the real costs have continuously fallen. The products in industrialized societies have become universal, and many of the good ones are within the reach of a large proportion of humanity. In keeping with this democratic trend of the century it was decided that people and their experiences with technology should be central to the encyclopedia. Readers are urged to read the entries in the light of the humanistic core.

An examination of people and their lives led to six broad, related areas of society from which the four hundred entries that comprise these volumes could be derived. The type of analysis carried out is indicated in the diagrams on the next page. The first shows the six basic areas; the second diagram is an outline of the detailed application for the category FOOD. Five or six levels of analysis allowed the definition of headers that provided the individual entries. Of course, entries could be found in two or more basic areas or could be related to others: entries in refrigerating in the domestic situation as found in food preservation would lead to entries in the technology of refrigeration *per se*. Thus the contents were defined.

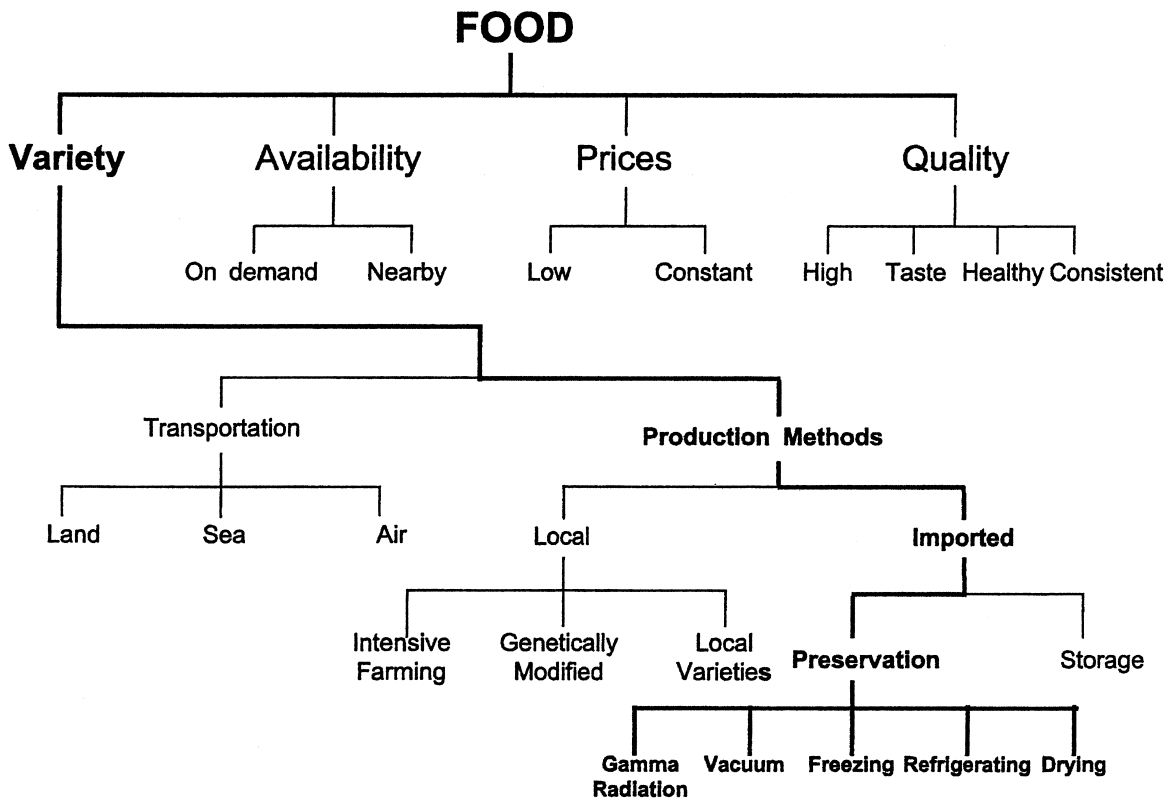
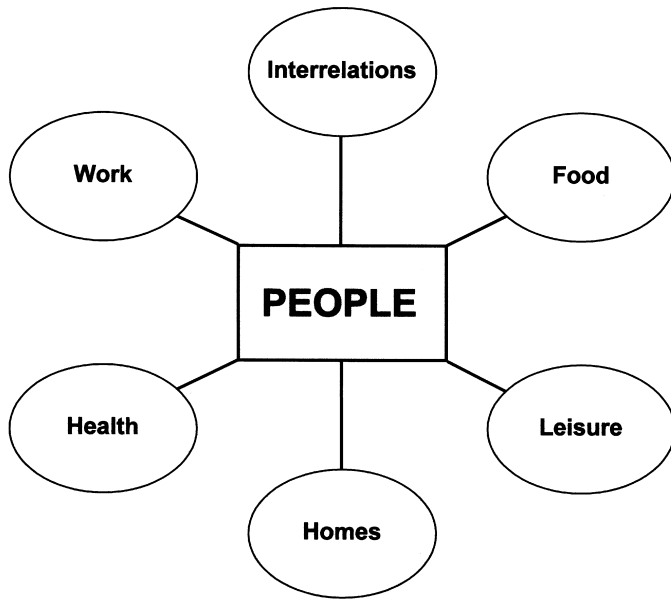
The encyclopedia contains two types of entries. The greatest number of entries are of 1000 words, and as far as possible these standard entries are devoid of interpretation. Nevertheless, it is recognized that all history is redolent of the era in which it is constructed, and this encyclopedia is of its own particular society, that of Western industrial. The

factual nature of the standard entries is leavened by longer essays in which historical and interpretative themes are explored. Among other things, these essays describe and analyze the relationship between society and technology, touch on the modern debates on the nature of the history of technology of history, and relate what people expect of the products of modern industrial civilisation.

The encyclopedia is concerned with 20th-century technology but not with 20th-century inventions. The technologies included are those that had an impact on the mass of the population in industrial societies. So many technologies invented in the 19th century did not begin to impinge markedly on many lives until the middle of the 20th century, so they are considered to be of the 20th century. Similarly, many products in the constructed world are old conceptions, transformed by modern materials or production methods. They have found a place in the encyclopedia. The inclusion of pre-20th-century products compares with the exclusion of recently developed technologies that have yet to have any effect on the mass of the public. However, the encyclopedia is not intended to be futuristic. In the 20th century, scientific engineering came to majority, and many if not all the products of modern technology can be seen to be the results of science. However, there are no entries that discuss science itself. Within the essays, however, science as science related to each subject is described.

Even with four hundred entries, the encyclopedia is not canonical, and gaps will be noted. However, the standard entries, the interpretative essays, and the lists of references and further reading suggestions allow readers to appreciate the breadth and depth of the technology of the 20th century.

**Colin Hempstead**



---

# Associate Editor's Preface

---

Technology is a vital subject. It grows continuously. New technologies are introduced, existing technologies evolve, and the outmoded are abandoned. Looking dispassionately at technology, it is always exciting, for it is the product of human ingenuity. For the purposes of this encyclopedia, we felt it could not and should not be discussed devoid of its human element. It is breathtaking to consider the panoply of developments which occurred during the last century, but it is necessary to recall that these developments did not take place in isolation. It was our desire to see that events, where possible, were described in context. Thus, you will find names, places, dates, and events critical to the development of a particular technology. The reader will note that some entries contain a surprising amount of information on 19th-century events. This was appropriate, for some 20th-century technologies were firmly rooted in that earlier time and can be best understood in light of the past. To avoid a deadly dull recitation of formulae and regurgitation of dry facts, we sought to give the reader the broadest possible picture.

The encyclopedia was created for the lay reader and students as well as for historians of science and technology. In light of this, we attempted to minimize the use of the jargon that tends to grow

around some technologies. Although many of the subjects are highly technical, our belief was that even complicated subjects could be rendered in such a way as to make them comprehensible to a wide audience. In the same way that an electrical engineer might need explanations when encountering genetic terminology, students and non-specialists will also appreciate the clarification. Because of the pervasiveness of the subjects in all facets of our lives, the encyclopedia should be a handy reference tool for a broad range of readers. Our aim was to make the subjects, which many of us deal with daily and do not necessarily grasp completely, readily understood with a minimum need for additional reference. However, should the reader wish to delve further into any particular subject, our expert authors have provided a selection of further bibliographic readings with which to begin.

The scope of the encyclopedia is intended to be international. Discussions were to be as inclusive as possible and avoid focus solely on the events of any one country. Nonetheless, some skewing was unavoidable due simply to the prodigious number of developments that have taken place in some countries.

**William E. Worthington, Jr.**



- [download online Toleration: A Critical Introduction online](#)
- [download Lost Histories of Indian Cricket: Battles Off the Pitch \(Sport in the Global Society\) here](#)
- [Queer Theory, Gender Theory: An Instant Primer book](#)
- [read online A Layman's Guide to Psychiatry and Psychoanalysis here](#)
  
- <http://www.khoi.dk/?books/Toleration--A-Critical-Introduction.pdf>
- <http://aircon.servicessingaporecompany.com/?lib/Lost-Histories-of-Indian-Cricket--Battles-Off-the-Pitch--Sport-in-the-Global-Society-.pdf>
- <http://studystategically.com/freebooks/Queer-Theory--Gender-Theory--An-Instant-Primer.pdf>
- <http://twilightblogs.com/library/Everything-to-Lose.pdf>