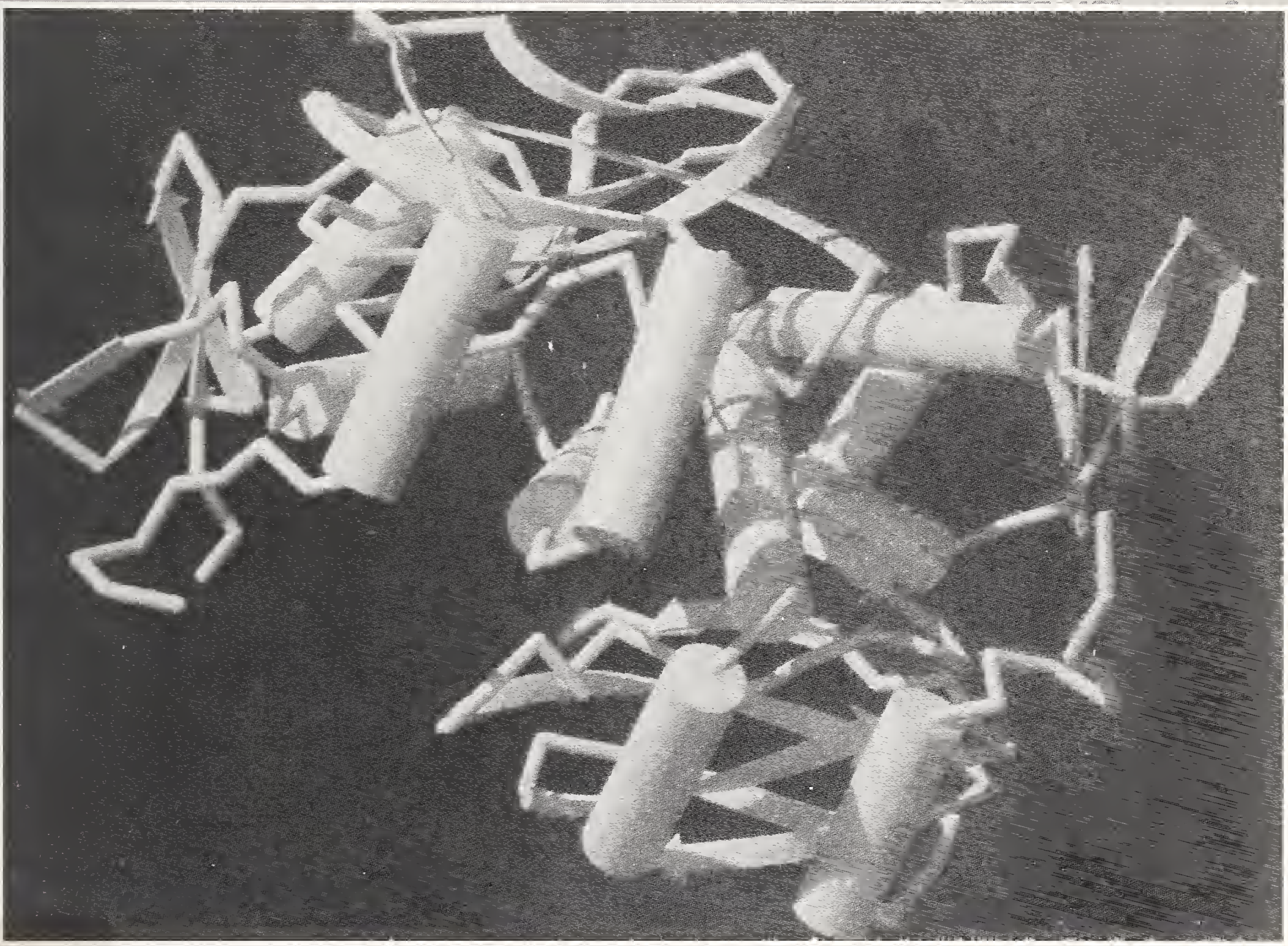
National Institute of Standards and Technology

NIST Research Reports



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On the cover: A computer-generated view of the protein that "turns on" genes. All life processes depend on transferring the coded information in the genetic material, or DNA, into useful proteins. In its active form this protein binds to DNA and triggers the decoding reactions. The diagram's cylinders and arrows represent different repeated shapes. David Bacon at the Center for Advanced Research in Biotechnology produced the drawing from structural information his colleagues deduced with x-ray crystallography. See article on page 18.

NIST Research Reports

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

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NIST

Research Update 2

The Long Road to Superconductivity 5

Following the Low Road 10

An Answer to the Challenge: Automation 13

Biotechnology Research Facility Dedicated 16

Switches That Turn On Genes 18

The Shop of the '90's 21

How To Reduce the Risk of 'Virus' Attacks 22

Performance of Steels Exposed to Fire Predicted 24

Model To Fight Fire Deaths, Costs 26

Data, Anyone? 28

New Publications 30

Conference Calendar 32

Research Update

Two U.S. Companies Receive Top Quality Award

Milliken & Company and Xerox Corp.'s Business Products and Systems, two U.S. manufacturing companies, received the 1989 Malcolm Baldrige National Quality Award on November 2 for superior quality in their management systems. President Bush, who presented the awards, praised the two companies for "leading the resurgence in American business leadership." Improvements in quality and service by American companies are "national priorities as never before," Bush said. The award, named after former Commerce Secretary Malcolm Baldrige, was established by legislation passed in August 1987. It promotes national awareness about the importance of improving total quality management and recognizes quality achievements of U.S. companies. The award is managed by NIST, with the active involvement of the private sector. For information on applying for the award, contact the Malcolm Baldrige National Quality Award Office, NIST, A1123 Administration Bldg., Gaithersburg, MD 20899.

Nontoxic Acids Are Basis for New Class of Cements

A new family of nonaqueous dental cements has been developed based on nontoxic dimer and trimer acids. They can be used in temporary fillings and liners, and as a foundation for other restorative materials. The new patented formulations use a dimer and/or a trimer acid derived from the partial polymerization of simple unsaturated fatty acids. These liquids can be mixed with a variety of basic powders used in restorative materials such as zinc oxide and calcium hydroxide. When mixed with powders, the bulky, flexible, hydrophobic nature of the dimer and trimer acids with their relatively low carboxylic acid content produce cements that are tough, low shrinking, water resistant, hydrolytically stable, and nonirritating. These new materials can be replacements for the eugenol cements that are mechanically and hydrolytically weak. For information, contact Joseph M. Antonucci, NIST, A143 Polymers Bldg., Gaithersburg, MD 20899, 301/975-6794.

Industry To Study Wear of Ceramics at NIST

The Carborundum Company, Inc., Niagara Falls, N.Y., is sponsoring a Research Associate Program at NIST to study the tribological characteristics of ceramics and ceramic composites under various temperatures. Carborundum researchers will use a NIST high-temperature wear test facility and other special equipment to conduct studies on the friction, wear, and mechanical behavior of advanced ceramic materials. NIST currently is conducting a tribology research program that includes advanced ceramics, coatings, and composites as well as the lubrication requirements of these materials. For further information, contact Said Jahanmir, NIST, A215 Metrology Bldg., Gaithersburg, MD 20899, 301/975-3671.

NIST Launches Consortium To Develop Futuristic Lab

With the goal of pooling the resources of industry, government, and academia to develop a totally automated analytical chemistry laboratory, NIST has instituted the Consortium on Automated Analytical Laboratory Systems (CAALS). In the laboratories of the future, automated devices—including robots—will perform the entire analytical procedure under the control of a sophisticated computer system. Analytical laboratory work often is labor intensive, performed by high-cost employees using expensive equipment. This makes the millions of yearly chemical analyses quite costly to industry and underscores the potential benefits of an automated laboratory. CAALS will pool the resources of a variety of experts to create a world-class team that will produce a viable robotics system that can be freely adapted. For information on participating, contact H.M. (Skip) Kingston, NIST, A353 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-4136.

New Database Will Compile OSI Test Results

In a move to speed the development and use of commercial networking products in industry and government, NIST and partners from private industry are developing a computerized database of commercial products that have implemented successfully the Open Systems Interconnection (OSI) standards and are interoperable. The participating vendors will test their products using OSINET, an experimental computer network coordinated by NIST. When it is established, users will have free, on-line access to the results. Vendors participating include Digital Equipment Corp., Hewlett-Packard, IBM, NCR, Retix, Touch Communications, Unisys, The Wollongong Group, and Xerox. For further information, contact Gerard Mulvenna, NIST, B217 Technology Bldg., Gaithersburg, MD 20899.

Improving Purity of Diode Lasers

Using optical feedback and electronic techniques, NIST scientists have achieved a 10,000-fold improvement on the color purity of commercial diode lasers. Typical diode lasers have spectral linewidths the range of colors emitted that are tens of megahertz wide; NIST scientists obtained linewidths of less than 1 kilohertz. The techniques also automatically stabilize the laser's oscillation frequency. The narrow linewidths and frequency stabilization make the diode lasers, which have low cost and high efficiency, attractive for applications in high-resolution spectroscopy and precision measurements. Narrow laser linewidth will also be a key feature in the next generation of lightwave communication technologies. Additional studies involving modification of the diode lasers, such as changes in the antireflective coatings, will be undertaken. Two papers outlining some of the techniques are available from Jo Emery, NIST, Division 104, Boulder, CO 80303, 303/497-3237.

Soft-Drink Glass Bottle Standard Revised

NIST has published a replacement voluntary product standard on glass bottles for carbonated soft drinks. The standard, which supersedes PS 73-77, is for manufacturing requirements to improve the safety performance of refillable and nonrefillable glass bottles made from soda-lime-silica glass with nominal capacities up to 36 fluid ounces. It was sponsored by the Glass Packaging Institute, Inc., and developed by a standing committee of representatives from soft-drink bottle manufacturers, bottlers, consumers, and others interested in performance requirements, inspection, and testing procedures for soft-drink bottles. NIST, a nonregulatory agency, administers the U.S. Department of Commerce Voluntary Products Standards Program in support of private-sector standards development. Specific activities are initiated in response to requests from interested parties and subsequent approval by the Secretary of Commerce. To obtain a copy of Voluntary Product Standard PS 73-89, *Glass Bottles for Carbonated Soft Drinks*, send a self-addressed mailing label to the Office of Standards Management, NIST, A625 Administration Bldg., Gaithersburg, MD 20899, 301/975-4023.

New Material Will Help Gauge Cholesterol in Eggs

A new NIST Standard Reference Material (SRM) can help researchers produce accurate data on how much cholesterol is present in egg samples. Laboratories can use the NIST materials to develop cholesterol-measuring methods or to validate existing techniques. The SRM consists of three capped glass bottles, each containing 8 grams of dried whole egg powder certified to have a cholesterol concentration of 19.0 milligrams per gram, plus or minus 0.2 mg/g. It is available for $95 from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

Copper Reduces Toxicity of Burning Polyurethane

Adding a minute amount of copper to flexible polyurethane foam, widely used as padding in upholstered furniture, can reduce the toxicity of smoke during a fire, say researchers at the NIST Center for Fire Research. Hydrogen cyanide (HCN), a colorless, highly toxic gas, is among the toxicants that can be produced when nitrogen-containing materials such as polyurethane foam burn. NIST researchers found that adding as little as 0.1 percent of copper to the foam significantly reduced both the atmospheric concentration of hydrogen cyanide and the toxicity of the smoke. For several years, the project has been sponsored partially by the International Copper Association Ltd. In the upcoming year, the Society of the Plastics Industry also will be lending support. According to the National Fire Protection Association, each year in the United States about 1,600 people die in 70,000 fires that begin with a cigarette that is dropped onto furniture, the bulk of which contains polyurethane foam. Overall, about 6,000 people die in fires in the United States each year. Most of these deaths are due to smoke inhalation and not to burns.

Educational Version of DIPPR Database Available

A special educational version of DIPPR (Design Institute for Physical Property Data) *Data Compilation of Pure Compounds, 1989* is available for chemistry students on diskette or tape. The new database provides students with quick access to important information on the behavior of substances and their reactions under various pressures and temperatures. It contains evaluated data on 39 properties for 100 chemical compounds most frequently used in classroom exercises. For the chemicals selected, data are provided on their thermodynamic, physical, and transport properties. Designed specifically as a teaching tool, the database is not for research use because of the limited number of available chemicals. NIST Standard Reference Database 11A, DIPPR, *Student (Educational) Data*

Compilation of Pure Compound Properties, 1989, is available for $75 from the Office of Standard Reference Data, NIST, A323 Physics Bldg., Gaithersburg, MD 20899, 301/975-2208.

Accurate Gauging of Food Components Is Aim of RM's

Scientists are continually striving to make accurate measurements of nutrients and contaminants in food samples. But they need standards to ensure the reliability of instruments and analytical methods—preferably standards containing a variety of foods representative of an American diet. A reference material (RM) now available from NIST offers just such a dietary composite complete with values for a variety of nutritional and potentially toxic components. The material contains listed concentrations of 17 elements as well as ash, fat, protein, total sugar, and starch. Food chemists can analyze the RM as they would any food sample and compare their results with the numbers provided. The material, known as Mixed Diet (RM 8431A), is available for $114 from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

Hearing Announced on Federal Role in Standards

Whether or not the U.S. standards systems, as they now exist, adequately serve the nation's trading needs in today's international markets will be the topic of a special public hearing on April 3, 1990. Marketing, manufacturing, engineering, and design professionals are invited to testify at the NIST-sponsored hearing. They will be asked to comment on what the U.S. role should be in international standards, describe any problems associated with the acceptance of U.S. products in foreign markets, assess the current situation, and provide suggestions for improvement. Information and comments will be used to make recommendations to the Secretary of Commerce to improve the effectiveness of U.S. participation in international standards-related activities. A written request to participate in the hearing should be submitted by Mar. 22, 1990, to Stanley I. Warshaw, Office of Standards Services, NIST, A603 Administration Bldg., Gaithersburg, MD 20899, 301/975-4000. The hearing will be held at 9:30 a.m. in the auditorium of the Department of Commerce in Washington, D.C. Individuals unable to attend may submit written comments to Warshaw.

Making Sound Business Decisions on Automation

AutoMan, a microcomputer program developed at NIST, applies modern mathematical techniques to make factory automation decisions easier. Choosing whether or not to invest in automated manufacturing equipment is a complex problem for shop and factory owners. AutoMan, developed for the U.S. Navy's Manufacturing Technology Program, allows managers to account for important gains realized by automation, including engineering performance improvements, better control over manufacturing, and improved product quality, as well as harder-to-handle intangible benefits like technology advancement, plant modernization, flexibility, and competitive position. The program for MS-DOS-based machines is available from the National Technical Information Service, Springfield, VA 22161 for $40 plus $3 for shipping and handling. Orders may be placed by phone: 703/487-4650. Order by PB# 89-221741. Please specify diskette size 5.25 or 3.5.

New Center for Dental Materials Research Announced

A new Center of Excellence for Materials Science Research has been established to expand the internationally recognized dental and medical materials program at NIST. The center is funded by a 5-year grant from the National Institute of Dental Research (NIDR). The NIDR grant was made to the American Dental Association Health Foundation (ADAHF), which maintains the Paffenbarger Research Center at NIST. The first year award is for $307,238, with additional funding to be appropriated over the 5-year period. Initial research projects will include: developing glass ceramic inserts to strengthen and stabilize composite dental restorations; improving the properties of resin-based composite dental materials to reduce shrinkage; and developing protective coatings for both enamel and dentin to prevent caries on exposed roots and to seal restorations.

NIST Helping To Modernize IRS Computer System

The NIST National Computer Systems Laboratory recently signed an agreement to provide technical support to the Internal Revenue Service (IRS) in its redesign of the tax administration system. One of the major goals of the project is to ensure that future technologies can be incorporated into the system without disruption or redesign. IRS will look to NIST for technical guidance in the final design, specification, implementation, and testing of a system. Also as part of the agreement, NIST will provide technical evaluations regarding various hardware and software architectures and technology. Plans call for the project to be completed by October 1991.

The Long Road to Superconductivity

Three years ago, the new "high-temperature" superconductors burst forth, bringing popular visions of unlimited power storage, fantastically fast computers, resistance-free power lines, and trains levitated above their tracks. These new materials, like precocious children, promised a great future because of their talent for conducting electricity without losing any energy. Ordinary wires conducting electric current waste energy by converting it to heat. In the ideal case, superconductors conduct with no resistance—electricity could circle a loop of superconducting wire forever. This ability to superconduct is not new. The "low-temperature" superconductors did this trick for years, but only when cooled with expensive liquid helium to a few degrees above absolute zero. The new high-temperature materials become superconducting in the relative warmth of cheaper liquid nitrogen, at 77 kelvins (−321 °F).

After several years of research, however, the new superconductors have proved difficult children. Scientists have toiled to train these materials to do useful work. These new superconductors tend to balk at carrying high levels of power or generating powerful magnetic fields—refusing to function under a substantial current or magnetic field. To make matters worse, these brittle ceramic materials often shatter when pushed to become a useful shape, such as a wire.

Today, scientists and engineers still struggle to get their stubborn prodigies to behave. At NIST, in both its Gaithersburg, Md., and Boulder, Colo., laboratories, experts in physics, chemistry, ceramics, and electronics chip away at the superconductivity problem.

Scientists at NIST were well-prepared for the arrival of the new superconductors—they had been studying the low-temperature variety for some time. "We have worked with superconductivity for more than 20 years," says NIST's Frederick Fickett, who heads Boulder's superconductor and magnetic measurements group. (See article on page 10.)

Low-temperature superconductors already run many devices. "Our work with low-temperature superconductors applies directly to research on the high-temperature ones," says NIST electronics expert Richard Harris. "We use the low-temperature devices as models for future high-temperature ones."

NIST researchers now contribute to the effort to surmount the many obstacles in the path to workable high-temperature superconductivity. Some are learning to measure key properties of the materials and to tailor these properties, seeking the conditions under which the superconductors behave best. Other NIST scientists are trying to unravel the still unsolved mystery of how the high-temperature superconductors work, using mathematical models, electrons, protons, and neutrons to probe the materials.

Superconductors function differently from ordinary metal

Editor's note: This article describes only a portion of the high-temperature superconductivity research under way at NIST. For a complete listing of papers or a collection of abstracts published by NIST researchers on this subject, send a self-addressed mailing label to Edie DeWeese, NIST, 724.00, Boulder, CO 80303.

NIST physicist Ronald Goldfarb inserts a high-temperature sample into an ac susceptometer for magnetic measurements.

conductors. In an ordinary conductor, electric charges tumble along their way, bumping into metal atoms as they go. Imperfections and unruly vibrations in the atomic arrangements hinder the electrons' paths, creating the "resistance" that steals energy from ordinary conducting cables and wires. In a superconductor, on the other hand, electrons pair up and maneuver gracefully through shifting spaces in the material's crystal lattice, moving in rhythm with its atomic vibrations.

In low-temperature superconductors, theorists believe that atomic vibrations act to pair the electrons, enabling them to flow unimpeded. However, scientists aren't sure the new high-temperature superconductors work the same way. Some researchers suspect some type of magnetic force may play a role, but the process remains a mystery. NIST scientist David Penn is collaborating with Marvin Cohen, of the University of California at Berkeley, to develop theories for the process.

Meanwhile, NIST physicist James Rhyne and his colleagues have uncovered some of the first clues to the mystery by looking into the superconducting materials with neutrons. Neutrons work much like x rays to reveal the inner structure of materials. Probing with neutrons from the NIST research reactor, Rhyne's group has improved our picture of the arrangement of individual atoms in crystals of the first known high-temperature superconductor, yttrium-barium-copper oxide (YBCO).

Recently, Rhyne replaced various atoms in the superconductor to determine which ones contribute to superconductivity. He explains that copper atoms sit in two kinds of sites—chains and planes. He found that replacing copper in the plane sites destroys superconductivity, but replacing the chain copper atoms leaves it unaffected. He concludes that superconducting current travels along the planes, not the chains.

Surface scientist Richard Kurtz and his colleagues also study superconducting materials, including YBCO, but use light rather than neutrons. They investigate the character of electrons in the material to determine which ones stay bound to atoms and which ones help superconduct. Many scientists originally believed copper in YBCO gave up three electrons. The surface scientists' investigation supported a different scenario—with these copper atoms only giving up two electrons and the superconductivity traveling via a missing electron or "hole" associated with the oxygen atoms. By using light from a synchrotron radiation source to probe specific atomic sites, NIST physicist David Ederer and his colleagues provided additional convincing evidence for this view.

Resistance-free current flow tells only half the story about superconductors' special properties. Magnetism reveals the other half. Magnetism comes inseparably intertwined with electric effects. Magnetic, as well as electrical, properties distinguish superconductors from ordinary materials. "You need two criteria to confirm superconductivity," says NIST magnetism expert Robert Shull. "You need to measure zero electrical resistance and to show the material expels a magnetic field."

Shull explains that an ordinary magnet generates a magnetic field—a force field that loops around the magnet, penetrating like a ghost through nearby objects. But a field will avoid the inside of a superconductor. Place a superconductor near the magnet and the superconductor will push some or all of the magnet's field out of its interior. The superconductor actually does this by creating its own magnetic field equal and opposite to the one from the external magnet. In the ideal case, the total field inside the superconductor adds up to zero.

By creating such a counteracting field, the superconductor becomes a temporary magnet—or diamagnet—oriented in the opposite direction to the actual magnet. Because of their opposite directions, the magnet and superconductor repel each other. A small bit of superconducting material will float above the magnet, suspended in air like the levitated lady in a magic show.

Magnetic measurement groups in Boulder and Gaithersburg have provided many important measurements detailing the magnetic behavior of superconductors and have used magnetic behavior to measure the superconducting ability of many materials.

Shull and his NIST colleagues identify superconductors by their ability to expel a magnetic field, or in other words, become diamagnetic. NIST researchers have measured magnetism to confirm superconductivity of an important bismuth superconductor and show several claims of room-temperature superconductors to be invalid.

When heated above their critical temperature or fed too much current, superconductors suddenly lose both their ability to conduct current without resistance and their ability to expel a magnetic field. The NIST magnetic measurement groups use the changes in magnetism to determine the temperature above which these materials revert from superconducting to normal behavior.

Engineers need to know these current and temperature limits to develop superconductor applications—whether as power storage devices, magnets, or electronic switches. The engineer must know under what conditions these finicky materials will or won't work.

The researchers note that only certain ideal, "type I" superconductors can expel magnetic fields completely. The more useful sort—"type II"—behave in a more complicated way, says Shull. The type II materials let in little bits of magnetic field while remaining superconductors. Instead of spreading out through the material uniformly—the field penetrates in small units called fluxoids. When the superconductor leaves the magnetic field, some of these penetrating bits of field get trapped inside.

Rhyne's group has improved our picture of the arrangement of individual atoms in crystals of YBCO.

This trapped magnetic field led to an effect called attractive levitation. NIST scientist Lawrence Bennett and his colleagues offered the first explanation of the phenomenon. He demonstrates the effect with a magnet and a small piece of high-temperature superconductor cooled in liquid nitrogen. First, he brings the magnet near the superconductor. The two materials repel each other. As he brings the magnet closer, the superconductor suddenly changes its mind, becoming attracted to the magnet. As Bennett lifts the magnet into the air, the superconductor follows it upward and then hangs suspended slightly below the magnet as if hung by invisible thread.

"When I push the magnet close enough," he explains, "some of its magnetic field gets pushed into the superconductor and sticks there." When that happens, the superconductor becomes a magnet with its poles directed so it attracts the external magnet.

Invading magnetic flux can also destroy superconductivity, creating one of the most frustrating roadblocks in high-temperature superconductivity research. In high-temperature materials, relatively small magnetic fields drastically cut down the current that a superconductor can carry before losing its superconducting power. Researchers find these fiendish fields impossible to escape. Even with no external field, simply running an electric current through a material can generate a magnetic field strong enough to break down its superconductivity.

The higher the external magnetic field, the lower the current a superconductor can bear before reverting to normal behavior. NIST physicist John Ekin and his colleagues have measured the amount of current the major types of superconductors can carry under a range of magnetic field strengths spanning five orders of magnitude.

How can a magnetic field hamper superconductivity? Threading through the material in thin lines, the strings of magnetic field create a resistance when moved. Electric currents drag these flux lines across the material and dissipate energy in the process: Hence no more superconductivity.

Under the right conditions, such as low temperatures, a current can race unhindered over flux lines because the lines stay "pinned" in place. Physical defects in the crystal lattice actually set up a snare to create what scientists call flux pinning. This pinning works best in low-temperature superconductors. In the high-temperature variety, more flux lines can get up enough energy to break free from their snares.

Researchers are identifying the kinds of defects that pin flux, hoping eventually to encourage the right defects, controlling flux pinning to make better-behaved superconductors. In the YBCO superconductors, scientists had suspected discontinuities called twinning planes may snag flux lines. Such a plane occurs when part of the asymmetrical YBCO crystal lattice runs into another part facing in a different direction. This leaves a boundary plane between the two "twin" crystals.

NIST scientists Debra Kaiser and Frank Gayle devised a way to squeeze the twin boundaries out of a YBCO crystal, pressing it so all pieces of the crystal line up in the same direction. By comparing the "untwinned" crystals with normal ones, they and their colleagues in magnetic materials found the special untwinned crystals superconducted virtually as well as the normal ones. Kaiser and Gayle concluded that the untwinned crystals must still pin flux: Structures other than twin boundaries must be holding the magnetic flux lines in place.

The magnetic flux problem hinders superconductivity across tiny units of the material—individual grains. Bigger problems beset superconductivity in the "bulk" ceramics, where many grains crowd together. "Individual grains superconduct pretty well," says NIST ceramics expert Stephen Freiman, "but things get much worse when you put grains together." Impurities and nonsuperconducting mixtures tend to collect in the boundaries between grains, destroying the superconductivity of the whole material. Misalignments between adjoining crystal grains can also derail the superconducting current. Sometimes superconducting current can travel via a weak "coupling" between grains, but Ekin and Ronald Goldfarb's work showed that small magnetic fields can break down the tenuous coupling between grains in these materials.

NIST researchers experiment with the process of making superconductors, learning to minimize these problems. NIST chemists and ceramics experts study every phase of the ceramic-making process, from mixing the ingredients in the right proportions, to "sintering" the powder into a solid superconducting material, to shaping the solid material. Companies interested in making superconductors often use NIST-produced recipes known as phase diagrams that show the proper mix of ingredients and the conditions, such as temperature and pressure, needed to make a superconducting material.

Researchers then face the problem of connecting the superconductors to ordinary wires without creating a barrier to superconductivity at the boundary between the two materials. A region with too much or too little oxygen will cause such a blockage. Ekin, working with researchers from the Westinghouse Research and Development Center, Pittsburgh, Pa., invented a solution to the problem by coating the superconductor area with silver before connecting it to the ordinary wire. Since oxygen can diffuse through silver, he found he could control the amount of oxygen at the boundary region, achieving the best mix for superconductivity.

Right now, researchers are meeting success coaxing high-temperature superconductors to carry higher currents by condensing thin-film coatings of superconducting materials on nonsuperconducting surfaces. Harris' cryoelectronics group makes these films from a vaporized material or a mixture of vapors of the material's constituents. The researchers make a vapor from a solid sample either by heating it or by bombarding it with lasers or energetic ions to knock atoms and molecules off into the vapor phase.

By choosing the right surface, the researchers can force the material to condense into the pattern of a single crystal with no superconductivity-killing boundaries. In this form, the materials conduct greater currents and avoid the pitfalls from grain boundaries that besiege thicker "bulk" shapes.

Harris says high-temperature superconducting films may be used in electronic devices such as detectors for magnetism and radiation. For example, NIST scientists are developing an infrared radiation detector called a bolometer that may use high-temperature superconductor films. Kept near its critical temperature, the superconductor registers radiation by changing from a superconducting to a normal state as the radiation boosts its temperature.

Harris' group also worked on a collaborative project with AT&T in applying semiconductor-making techniques to superconductors. The team investigated ways to form very small structures, like those etched onto computer chips, onto a superconducting material. Low-temperature superconductors already make up a variety of useful electronic devices, and the NIST researchers hope to make similar devices from the new high-temperature materials.

NIST physicist Todd Harvey observes sputter deposition of high-temperature superconducting thin films used by NIST to develop electronic measuring devices.

NIST researchers still hold high expectations for the new high-temperature superconductors. "The technology is only 3 years old; there's still a lot to learn," says Fickett. "I'm as enthusiastic as I ever was."

Robert Kamper, head of the NIST superconductivity program, recalls the way low-temperature superconductivity research faltered at its beginning. After a Dutch scientist discovered superconductivity in a very cold mercury wire in 1911, scientists rushed to make super strong magnets and energy storage devices. Before long they ran up against nearly impossible problems getting these materials to carry high currents or work in high-magnetic fields. Not until the 1960's did researchers finally overcome enough hurdles to sell useful devices using the low-temperature superconductors.

"In the past, nearly insurmountable problems cropped up but people solved them," says Kamper. "I'm sure people will be able to design around the problems we now have with the high-temperature superconductors, too."

by Faye Flam
NIST Writer-Editor

Following the Low Road

While researchers lavish attention on the newborn "high-temperature" superconductors, the older, low-temperature superconductors have already led to many applications of superconductivity. "The recent discovery of new high-temperature materials renewed interest in the conventional superconductors that have been around since 1911," says Frederick Fickett, head of the NIST superconductor and magnetic measurements group.

Both types conduct an electrical "supercurrent" that loses no energy in its passage. The low-temperature superconductors—generally the metal alloy of niobium and titanium or a compound of niobium and tin—work only when cooled with liquid helium to near absolute zero. The new high-temperature materials stole the show in 1986 by working with much less cooling. However, the path to useful high-temperature superconductivity soon twisted into a maze of obstacles: The brittle materials proved hard to work with, pervasive magnetic fields destroyed superconductivity, and boundaries between "grains" of the material blocked the supercurrent. Low-temperature superconductors, on the other hand, avoid most of these pitfalls.

"In the short run we may find it easier and cheaper to cool the low-temperature superconductors the extra amount than to overcome the problems with high-temperature superconductivity," says NIST physicist James Rhyne.

As scores of researchers drive toward the development of superconductivity, NIST provides road maps. NIST researchers take these materials and describe them and measure their key properties. Scientists and engineers working with superconductors turn to NIST for data on their material's magnetic properties and current-carrying capability. NIST scientists also seek a better understanding of how these materials work and experiment with applications.

Scientists and engineers working with superconductors turn to NIST for data on their material's magnetic properties and current-carrying capability.

Superconductors have been applied in two main ways: as electronic circuit elements and as magnets. Today, low-temperature superconducting magnets run many devices, including medical imaging machines, particle colliders for physics experiments, a Navy ship, and a Japanese levitated train. Scientists envision using superconducting magnets to squeeze atoms together in fusion energy plants.

How does a superconductor become a magnet? Electric current running through a coil of superconducting wire generates a magnetic field running through the coil. But too much current or too powerful a magnetic field will destroy superconductivity. Therefore, anyone using superconductors for magnets needs to know the limits of the material. Scientists in the NIST superconductor and magnetic measurements group provide the measurement techniques and the data to determine how much current, magnetic field, and mechanical strain will break down a magnet's superconductivity. They also study how superconductors behave under alternating currents.

In addition to providing measurements, NIST scientists have contributed to the design of magnets for particle accelerators used in experiments probing the fundamental laws of nature. Some of these magnets will guide particles down the 50-mile path of the proposed superconducting supercollider in Texas, for example.

Superconductors can also do big things in very small amounts. Two bits of superconductor with a slice of poorly conducting, high-resistance material sandwiched between them make up a tiny electronic component called a Josephson junction. Like transistors in the world of semiconductors, Josephson junctions process electrical current by switching between two states—"on" and "off."

In the "off" state, the whole sandwich superconducts. A tendency called the "Josephson effect" allows the supercurrent to ignore the middle layer, losing no energy as it jumps across the high-resistance material. Raising the current past some critical value switches the junction to the other state—the "on" state. In this second state the junction conducts an ordinary current that loses energy, especially when squeezing through the high-resistance middle piece.

NIST physicist Loren Goodrich lowers a test cryostat containing a high-current niobium-titanium superconductor into a high-field magnet for critical current testing.

Scientists in NIST's cryoelectronics group experiment with hooking together Josephson junctions into useful devices. Several years ago they created an instrument that uses thousands of Josephson junctions to provide a standard measurement of voltage. A copy of this instrument enabled the Hewlett Packard Company to define the accuracy of a new (conventional electronic) digital multimeter and go to market with world-beating specifications.

Low-temperature superconductors also gave rise to an analog-to-digital converter. The device takes a smooth signal, such as a song on the radio, and approximates it as a series of discrete digits. The military is developing the device for instruments that detect heat. Such detectors could map out climate patterns over a continent or detect the heat of a missile.

Another application of Josephson junctions—the SQUID—also detects targets, in this case by sensing magnetic fields. Though this SQUID doesn't swim in the sea, the military is training it to sniff out submarines and underwater mines. SQUID's—for superconducting quantum interference devices—take advantage of the way small magnetic fields can break down superconductivity. The SQUID registers a magnetic field when the field switches its Josephson junctions out of the superconducting state.

NIST researchers also are making SQUID's to help Stanford University scientists verify a prediction that follows from Einstein's general theory of relativity—that a gyroscope will wobble when moved through a gravitational field. The scientists are looking for such a tiny wobble that they need a special gyroscope that gains extra sensitivity from superconductors.

A gyroscope works like a fast spinning top with no friction to drag it down. Its axis of rotation holds the same angle until some force pushes on the axis, making it wobble, or precess like the axis of a top slowing down.

NIST electronics engineer Clark Hamilton examines the 1-volt Josephson series array voltage standard. With about 3,000 junctions, these NIST-fabricated integrated circuits are used in standards laboratories around the world.

In the superconducting gyroscope, a spinning quartz ball coated with a superconductor will generate a small magnetic field when its axis wobbles. Scientists plan to detect this field with a superconducting detector—the SQUID. The Stanford researchers expect to launch the experimental apparatus on the next space shuttle.

Superconductors have been applied in two main ways: as electronic circuit elements and as magnets.

Much of the NIST research focuses attention on combining superconducting electronic elements into complex arrangements—analogous to computer chips. The researchers create patterns of Josephson junctions. Since resistance in the circuits now limits the speed and power of electrical devices, resistance-free Josephson junctions may lead to much faster electronics.

NIST researchers say their work with the low-temperature materials may eventually be applied to the new high-temperature ones. Both low- and high-temperature superconductors promise to break past many limits further down the road. *F.F.*

An Answer to the Challenge: Automation

Without minimizing the importance of the service industry to the country's economic health, I think I can safely assert that manufacturing is crucial to our economic and military security and to the viability of our culture. In short, "manufacturing matters." New advances in automated manufacturing technology—robots, computerized machine tools, artificial intelligence, computer-aided design techniques, and integrated flexible automated manufacturing systems, for example—can make dramatic changes in the country's manufacturing position.

These advances can improve production operations of U.S. operations from the standpoint of quality, productivity, product-life cycle, materials conservation, human resource utilization, and cost. Such improvements, in turn, affect the relative strength of our manufacturing enterprise and have an immediate effect on our defense industrial base.

The Japanese and others are aggressively exploiting the potential of advanced and automated manufacturing. I find it very worrisome that in Japan approximately 30 percent of all machine tools are computer-controlled compared with the automation of only about 10 percent of the machine tools in this country.

This article was excerpted from the keynote address given by Deputy Secretary of Commerce Thomas J. Murrin at the NIST Automation Open House on November 14, 1989.

Much of the work by NIST researchers is focused on applying advanced technology to manufacturing more effectively.

What is slowing the adoption of automated manufacturing? The cost and availability of capital is a big factor. So is the lack of technical expertise on the part of management and staff, along with a common failure to appreciate the importance of quality and productivity. There are problems of compatibility and reliability in equipment and software. Perhaps most important is the broader lack of long-term business strategies for managing companies in ways that allow them to take full advantage of automation.

How do we deal with these problems? What do we need to do to improve our competitive position in manufacturing? I believe there are five key ingredients to improved competitiveness for this country—and each has special relevance to automated manufacturing. Each must be understood and addressed *now* if the United States is going to take full advantage of automated manufacturing's potential.

First, we must assure that global competitiveness, including world-class manufacturing, is a top priority objective for U.S. industry. Second, we must do a far better job at educating and motivating our employees, *including* our managers. This also means getting more of our best-and-brightest college students to pursue studies and then careers in manufacturing technology.

In addition, we must apply advanced technology to manufacturing more effectively—including the use of concurrent engineering techniques. And, we must seek lower-cost sources of capital, while aggressively justifying new investments by anticipating the benefits that result: greatly improved quality; radically reduced inventory, building and equipment; more rapid commercialization of new products; and improved response to changing customer demands.

Finally, we must sustain quality and productivity improvement. Quality improvement—properly defined and effectively implemented in a total quality management approach—is one of the most significant secrets to the future success of our industrial base improvement.

While NIST appropriately places major emphasis on manufacturing technology, its automation program addresses each one of these key items.

The data-driven manufacturing techniques developed at NIST and employed at its Automated Manufacturing Research Facility are helping to equip U.S. manufacturers facing a global marketplace filled with strong competitors producing world-class products. NIST's heavy involvement in U.S. standards efforts, and in the international standards arena, is helping to assure that standards speed, rather than slow, U.S. automation efforts.

Much of the work by NIST researchers—both in the laboratory and on standards committees—is focused on applying advanced technology to manufacturing more effectively. This is much more than just a research and development program.

The activities at NIST help to justify new investments in automation equipment and systems by proving the benefits that can result—including more rapid commercialization of new products and improved response to customers' needs.

And the automation research at NIST aims to help build quality into the design and manufacturing process so that parts are made right the first time. Measurement is a key.

NIST's efforts are a model of how government, industry, and academe can join together to boost our manufacturing capabilities and overall competitiveness. More than 50 U.S. companies—large and small—have sponsored their researchers to work in NIST labs on automation-related projects. A similar number of firms have loaned or donated about $12 million worth of equipment to the automation program at NIST. The Department of Defense, especially the Navy, is a major supporter, and more than three dozen universities have connections with the program.

NIST's efforts are a model of how government, industry, and academe can join together. . . .

The work at NIST is paying dividends, helping to assure both our economic and military security. I truly am convinced that this work is crucial to improved manufacturing competitiveness for the United States.

There are dozens of specific instances in which NIST automation work has been transferred to help U.S. companies or government agencies take better advantage of automation technologies. Today, that process continues as NIST is:

- assisting the shipbuilding industry with data standards.
- developing theoretical results, participating in standards activities, and otherwise helping to solve a DOD-industry measurement problem identified with the use of coordinate measuring machines.
- developing a tool-management system for installation in the Army's Rock Island Arsenal.

It should be clear that technology cannot succeed in a vacuum, that we must do a far better job of managing the technology at our disposal. Business practices, human resource conditions, and the overall business climate will make all the difference in the world.

We need business-technology strategies that include concurrent engineering principles, that fully integrate R&D, manufacturing, and marketing functions. We need business-technology strategies that specifically take into account our competitors' advances and our own strengths and weaknesses.

NIST is addressing these broader business-technology issues as part of its traditional laboratory-based activities and as it carries out new responsibilities under the Omnibus Trade and Competitiveness Act of 1988. Under that law, NIST is charged with providing technical expertise and assisting small and medium-sized businesses to adopt automation techniques through Regional Manufacturing Technology Centers. Centers have been established in Ohio, New York, and South Carolina.

Each of the centers is using different approaches to survey manufacturers to evaluate client needs. Each center is defining the technologies and services appropriate for its region and is entering into cooperative agreements with vendors and professional organizations.

Satellite centers are being formed at community colleges and state-operated manufacturing resources centers. Technology "solution packages" are being developed to minimize "reinventing the wheel" each time a new manufacturer is assisted.

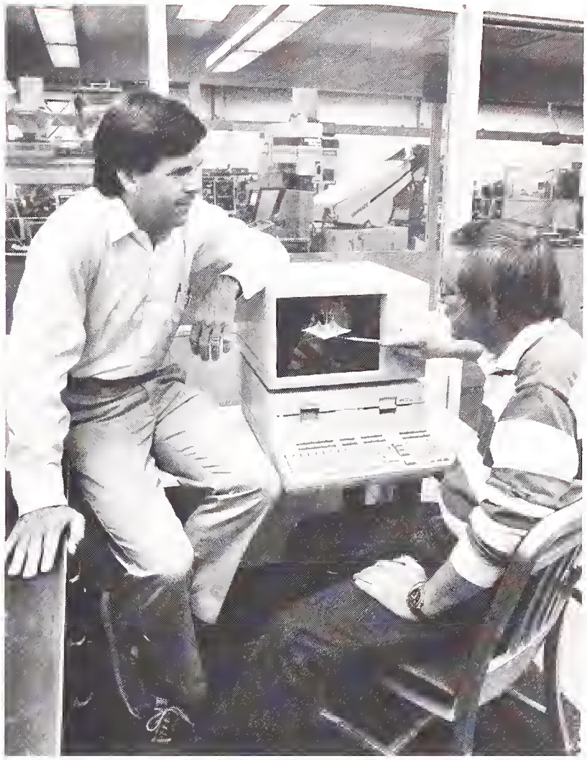
NIST also is involved as part of a Commerce Department Technology Administration team that has joined with other federal agencies to increase private-sector use of automated manufacturing techniques. These agencies include the Department of Defense, the Office of the U.S. Trade Representative, NASA, and the Small Business Administration. Among other things, this Interagency Working Group on Flexible Computer-Integrated Manufacturing is examining procurement and regulatory impediments to industry automation. For example, through this group, we are assisting DOD in examining industry accounting procedures which discourage investments in flexible automated manufacturing by using narrow financial criteria and by failing to take effectively into account factors such as throughput, lead-time, quality, and flexibility.

Major representatives of the American accounting industry are participating in an effort to change accounting practices that now act as barriers to automation investments. With Navy Mantech program support and in collaboration with a consortium of manufacturers, NIST has addressed the accounting issue by developing a software package which allows investors to include nonfinancial criteria in investment analyses. This new program is being tested by nearly 50 companies.

Another promising approach for encouraging greater adoption of automated manufacturing, especially by small and medium-sized firms, is shared flexible computer-integrated manufacturing, or FCIM. Promoted by the Technology Administration, which NIST is part of, a shared FCIM facility is an automated manufacturing service center that would lease manufacturing time to small firms. Such centers are still a new idea, with the first production operations now being established, but there is growing interest in the concept.

As we assess the global competitive environment, it is easy to see that U.S. manufacturing faces rough times ahead. We need to overcome substantial technology, business, political, and cultural barriers. Our success ultimately will depend on how well and how quickly we address each of these concerns. We already have spotted the Japanese a big lead—and other nations are striving to join them at the head of the pack. Now we've got to catch up.

It is through programs like those at NIST, through cooperative efforts that team our resources in industry, government, and academe, that our country can meet the challenges that await us.



Researchers at NIST are applying advanced technology to improve the effectiveness of manufacturing.

Biotechnology Research Facility Dedicated

University and government officials dedicated the new laboratory facilities of the Center for Advanced Research in Biotechnology (CARB) on November 29. One of the first biotechnology research establishments of its kind in the country, CARB is located at the Shady Grove Life Sciences Center in Montgomery County, Md., and is part of the Maryland Biotechnology Institute (MBI) of the University of Maryland System.

CARB was established in 1984 as a cooperative venture of the National Institute of Standards and Technology, the University of Maryland, and Montgomery County. It was one of the first biotechnology research efforts involving federal, state, and local governments in cooperation with a major university.

The new CARB laboratory facilities are located at the Shady Grove Life Sciences Center in Montgomery County, Md.

The new $7.6 million, 40,000-square-foot facility provides a world-class research center for multidisciplinary studies in protein structure, function, and design. Through close interaction with industry, CARB researchers are expected to narrow the gap between laboratory discoveries and industry needs.

In his keynote address, James Wyngaarden, Associate Director for Life Sciences, Office of Science and Technology Policy, said, "CARB is an important development, and a national resource for accelerating the rate of transfer of discoveries in biotechnology into practical uses of benefit to mankind. It is an outstanding example of government-university-industry collaboration, one that can make a difference in keeping this country at the forefront of competitiveness in biotechnology."

NIST Acting Director Raymond Kammer extended an invitation to the biotechnology industry to become involved in research at the center, saying, "Through its work on protein structure and molecular biology, CARB will provide information and tools essential to the biotechnology industry. Cooperative research agreements with private industry will speed the transfer of this knowledge and know-how. These industrial ties are of particular interest to NIST, with our long history of successful cooperative research ventures, so let me reiterate the standing invitation to the biotechnology community to learn how they can make use of this world-class facility."

The state-of-the-art laboratories at CARB are designed for critical areas of research in macromolecular structures and modeling. The highly instrumented

Researchers in the CARB protein crystallization laboratory prepare and examine protein crystals, a first step in determining the atomic structure of proteins.

laboratories include a computer and graphics laboratory with a state-of-the-art mini-supercomputer and several high-resolution interactive workstations, an x-ray crystallography laboratory, and laboratories for molecular biology and biophysical chemistry. A nuclear magnetic resonance (NMR) spectroscopy laboratory will be added this spring.

Currently the CARB staff totals 40—including 10 principal scientists (five from MBI and five from NIST) who are building research groups in crystallography, molecular biology, NMR spectroscopy, physical biochemistry, and computational chemistry and modeling. In addition, there are 12 staff scientists and technicians, four postdoctoral fellows, five graduate students, three visiting scientists, and six administrative support staff. The total CARB staff is expected to grow to approximately 70 over the next 2 to 3 years.

The CARB researchers are working to understand the structure and function of several important proteins and enzymes including: cytochrome P-450, an enzyme involved in cellular detoxification; beta-lactamase, an enzyme that bacteria use to resist penicillin-like drugs; and interleukin-1-beta, an important protein in the human immune system.

Research programs at CARB are managed jointly by the Maryland Biotechnology Institute and NIST. CARB is advised by a board of overseers chaired by Donald Johnson, acting director of NIST Technology Services.

The CARB opening also included the dedication of the Isadore M. Gudelsky Memorial. Through the generosity of the Isadore and Bertha Gudelsky Family Foundation, 50 acres of land were donated to Montgomery County. This site at Shady Grove will be developed by the University of Maryland Foundation. Montgomery County financed the construction of the CARB facility on the site and is leasing it to the University of Maryland foundation.

For information on research at CARB contact Director Thomas Poulos or Associate Director Walter Stevens, 9600 Gudelsky Drive, Rockville, MD 20850, 301/251-2272.

by Roger Rensberger
NIST Public Affairs Specialist

The CARB graphics laboratory is used for data analysis, simulations, and theoretical modeling of protein structures.

Switches That Turn On Genes

If you looked closely, you would see squads of proteins of assorted shapes doing all the work in your body. Some turn food into energy, some transport nutrients or waste products, others contract your arms and legs when you want to move. Nearly every cell in your body contains a complete set of genetic instructions for making all of the 100,000 or so human proteins—yet each individual cell knows to make just the right amount of the right proteins at the right times. A bone marrow cell makes oxygen-carrying hemoglobin, while an intestinal cell makes an enzyme to digest food, and an immune cell makes an antibody to fight foreign bacteria and viruses. Each plays its part like a musician adding to the complex symphony that brings creatures like us to life.

Who conducts the orchestra? What tells a cell to turn on the protein machinery to decode some gene? What turns it off when it has made enough? And how do the genes know to copy themselves before the cell divides?

We know that long, double-stranded DNA molecules hold the chemical code for constructing each protein. A series of reactions opens a DNA molecule, separates the two DNA strands, and translates the information coded in a segment, or gene, into a protein. But we have much to learn about how it all works.

Scientists at the Center for Advanced Research in Biotechnology (CARB) explore some of the unmapped territory. (See related article on page 16.) The experiments of NIST scientists Keith McKenney and Prasad Reddy and their colleagues in the molecular biology group give a close-up view of how different molecules signal each other to act. "We strive to understand these mechanisms in chemical terms," says McKenney. "With the tools and techniques of modern molecular biology we can begin to see in atomic detail how basic reactions work."

"With the tools and techniques of modern molecular biology we can begin to see in atomic detail how basic reactions work."

These tools include gene splicing (using enzymes to join DNA at precise points), gene recombination (linking genes from different DNA molecules), DNA synthesis (making DNA in a test tube), and molecular cloning (using a cell to copy added genes). These techniques enable the researchers to alter genes, reorganizing their code or sequences. By manipulating the genes, scientists can modify or "engineer" the proteins encoded in these genes. McKenney and Reddy learn how genes work by studying the action of their protein product.

Through their experiments, the researchers learn how fundamental processes work. McKenney notes that such research in molecular biology often leads to unforeseen practical uses within the world of biotechnology, for example, improved medical tools for making vaccines or diagnostic kits or better crops that resist disease and pests without pesticides.

McKenney and Reddy focus on two questions. First, what prompts genes to transcribe and translate their genetic code into a protein? Second, what triggers

DNA molecules to make copies of themselves to pass on to new cells? To explore the first question—on transcribing and translating genetic code into proteins—the researchers study molecular signals that trigger the different steps in the process. Scientists refer to such signals as molecular "switches" that turn a gene "on" or "off."

The CARB researchers experiment with the molecular switches of one of the Earth's simplest creatures, a single-celled bacterium called E. coli. McKenney and Reddy investigate the molecules that turn on genes that encode a group of proteins called enzymes. These particular enzymes break down sugars to extract energy from them.

Just digesting a sugar requires a complex set of steps for this simple bacterium. "When the cell senses a complex sugar like lactose, it turns on a cascade of reactions that leads to activation of a protein by a small molecule called cyclic AMP," McKenney says.

He explains that scientists have developed a clear picture of the last step, when an "activator" protein actually turns on the gene. This protein can read the chemical code written along the gene. Scientists use the four characters, A,G,C,T, to stand for the four chemical components of the gene, known as bases—adenine, guanine, cytosine, and thymine. The activator protein binds only to specific sequences of this code.

Left to right, University of Maryland DNA chemist Joel Hoskins, graduate student Kalidip Choudhury, NIST molecular biologist Keith McKenney, and graduate student Marc Kantorow examine the results of a DNA sequencing experiment at CARB.

The long, double strands of DNA containing the genes twist into a double helix with two different-sized grooves, like the grooves running around a screw. The activator protein has two "fingers" that fit into these grooves. One of these fingers locks into and "feels" a series of bases. In a string of some 5 million bases, this protein recognizes and locks into 50 different short sequences where it turns on production of 50 different enzymes, all useful in metabolizing sugars.

But before the activator protein can turn on these 50 genes, cyclic AMP must turn on the protein. The cyclic AMP grabs onto the protein and transforms its shape. It is this step that most interests McKenney and his colleagues.

It is the protein's three-dimensional structure that gives it its function. Only 20 different building blocks called amino acids link up to form all proteins, but each combination folds up into a unique, complicated configuration of bends and twists. The structure enables the protein to do its job, whether breaking down sugars, transporting oxygen, or activating genes. Though the little cyclic AMP is only one four-hundredth the size of the activator protein, it rearranges the three-dimensional structure enough to convert it from its inactive to its active form.

McKenney and his colleagues want to know how this small molecule binds to the activator protein and how it changes the structure. They are experimenting with altering this protein through protein engineering and determining how different changes alter the way the cyclic AMP activates the protein and the way the protein, in turn, activates the gene.

McKenney explains that by protein engineering they don't actually rearrange or remodel already-made proteins, but instead engineer the genes that code for the protein. "We add the altered gene to a cell and let it make the new activator protein," he says. "Then we see how the altered protein works. How well does it work? Does it respond to the cyclic AMP? Does it respond to any other small molecule? Can it still fold into its natural three-dimensional structure?"

The scientists have made hundreds of alterations in the activator protein by changing just one or two amino acid building blocks. Researchers then test these modified proteins to see if they can still do their job—in this case turning on genes that produce enzymes that break down a sugar.

In 80 percent of the alterations, the modified activator failed to turn on its target gene. Consequently, the cells failed to digest the sugar. In about 20 percent of the cases, though, the researchers changed the function of the activator protein without destroying its activity. McKenney considers those the interesting ones, worth further investigation.

"Once you go through the zoo of modified proteins and pull out the interesting ones, how do you characterize them?" he asks. He explains that scientists have developed a structural model describing how individual atoms and atomic groups interact when the cyclic AMP binds to the activator protein. The altered proteins help them to construct and verify this model. By changing different parts of the protein and noting subsequent changes in its function, the researchers can decipher which parts play a key role in recognizing the cyclic AMP molecule.

The researchers discovered that different small molecules—chemical cousins of cyclic AMP—activate some of the modified proteins. Comparing different small molecules provides insight into the way other molecular switches work as well.

"Once you go through the zoo of modified proteins and pull out the interesting ones, how do you characterize them?"

This particular case provides just one example of a molecular switch. It works as a "positive activator" because its presence turns the gene on. All sorts of other molecules activate other genes. Some switches keep genes turned off. These "repressor" proteins must release a gene before it can turn on.

Still other switches tell DNA molecules to reproduce, copying their information into new DNA that goes into new cells. Scientists have even more to learn about this second process.

In exploring this problem, the researchers study a virus-like particle called a phage that invades bacteria. The phage lives in the E. coli cell and takes over the cell's DNA duplicating machinery for its own use, churning out copies of its own DNA.

The phage needs several proteins from the host cell and one of its own to start reproducing its DNA. These proteins lock into specific sites on this DNA. The researchers know that one phage protein binds to five sites on its DNA and another protein from the bacterial host binds to two other sites. By altering both the sites on the phage DNA and the proteins that fit into them, the researchers are learning how these proteins trigger the DNA to copy itself. So far they have found the phage needs some of the binding sites to reproduce itself and can do without others. In some cases changing the position of binding sites stops replication, while changing others doesn't.

The CARB group expects this work to lead to important applications. Discovering the keys to genetic switches will enable people to control a cell's protein-making machinery, harnessing it to make large quantities of proteins useful in industry and medicine. *F.F.*

The Shop of the '90's

The shop of the '90's is not the "factory of the future," it's the factory of the here-and-now. The National Institute of Standards and Technology, well-known for its research at the forefront of automation technology, is solving the automation questions that exist today. Small job shops—operations with fewer than 50 employees—make up about 85 percent of U.S. metal fabrication facilities and account for about 75 percent of all U.S. metal fabrication. They are running substantially behind their overseas competitors in the use of modern technology. In Japan, for example, approximately 30 percent of all machine tools are computer-controlled as compared to fewer than 11 percent in the United States. Sweden and West Germany also have more computer-controlled equipment than the United States.

What modern technologies are commercially available, affordable, and useful to the small job shop? How are they best introduced? What return on investment might be expected? To help answer these questions, NIST is using its own job shop to conduct an experiment in the practical implementation of computer-integrated manufacturing.

The NIST Fabrication Technology Division (FTD) designs and manufactures specialized instruments and other equipment for the NIST laboratories. The workload is comparable to that of many small job shops in high-technology industries. FTD employs just over 50 people in its main shop and several on-site contact shops, using a wide variety of numerical-control (NC) and manual machine tools of varying vintages. Other duties include tool and material inventory and management, cost estimating, and billing.

In July 1988, FTD began a project to modernize and improve its own operations, creating the "Shop of the '90's." To make the project relevant to small, private-sector job shops, only affordable, commercially available "off-the-shelf" systems and software are being used. Purchases and changes are justified by a reasonable return on investment.

The project involves three stages:

- Conducting a thorough review and evaluation of existing machine tools and resources to provide a basis for decisions to repair or replace existing tools.
- Installing a personal computer network to support computer-aided cost estimation, computer-aided process planning, computerized tool room management, and computerized job and job cost tracking. In addition, design and manufacturing (CAD and CAM) systems based on personal computers were added to speed design and programming of parts.
- Training shop personnel in the use of the new systems and equipment.

The project has already demonstrated a three-fold reduction in NC programming time and, because of improved productivity, a 6-month payback time for new equipment.

NIST does not recommend particular products or suggest that the products used in the "Shop of the '90's" are the best for any other machine shop, but the principles and procedures developed in the program can be useful to many small shops.

FTD has established a "Shop of the '90's" seminar center, which replicates the FTD equipment and software on a small scale. The center is available to private industry for use in cooperative research programs, to test the compatibility of different software packages and similar tasks. For information, contact Adrian Moll, NIST, 136 Shops Bldg., Gaithersburg, MD 20899, 301/975-6504.

by Michael Baum
NIST Public Affairs Specialist

How To Reduce the Risk of 'Virus' Attacks

To reduce the risk of damage from potentially serious computer viruses, experts at the National Institute of Standards and Technology, the National Computer Security Center (NCSC), and the Software Engineering Institute (SEI) are recommending several measures plus common-sense computing practices. "This advice is being offered to encourage effective yet calm response to recent reports of a new variety of computer virus," says Dennis Steinauer, manager of the computer security management and evaluation group at NIST.

"Computer virus" is a term often used to indicate any self-replicating software that, under certain conditions, can destroy information in computers or disrupt networks. Other examples of malicious software are "Trojan horses" and "network worms." Viruses can spread quickly and can cause extensive damage. They pose a larger risk to personal computers, which tend to have fewer protection features and are often used by people who are not versed in the technical details of the machine. They frequently are written to masquerade as useful programs so that users are duped into copying them and sharing them with friends and work colleagues.

While incidents of malicious software attacks are relatively few, they have been increasing. Routine use of good computing practices can reduce the likelihood of contracting and spreading any virus and can minimize its effects if one does strike. Advice from the experts includes:

- Make frequent backups of your data and keep several versions.

Routine use of good computing practices can reduce the likelihood of contracting and spreading any virus. . . .

- Use only software obtained from reputable and reliable sources. Be very cautious of software from public sources, such as software bulletin boards, or sent across personal computer networks.
- Don't let others use your computer without your consent.
- Use care when exchanging software between computers at work or between your home computer and your office computer.
- Back up new software immediately after installation and use the backup copy whenever you need to restore. Retain original distribution diskettes in a safe location.
- Learn about your computer and the software you use and be able to distinguish between normal and abnormal system activity.
- If you suspect your system contains a virus, stop using it and get assistance from a knowledgeable individual.

In general, educating users is one of the best, most cost-effective steps to take, says Steinauer. Users should know about malicious software in general and the risks that it

More on Computer Security

Under the Computer Security Act of 1987, NIST is responsible for technical, management, physical, and administrative standards and guidelines for the cost-effective security and privacy of sensitive information in federal computer systems. NIST has published four new documents that federal agencies, and others, will find helpful in improving the security of sensitive information contained in computer systems.

A series of three guides addresses many of the computer security questions of executives, managers, and users. A fourth publication is a guideline to assist federal agencies in developing computer security training programs. They are available prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by the following titles and stock numbers: *Executive Guide to the Protection of Information Resources* (NIST SP 500-169), SN 003-003-02969-6, $1.50; *Management Guide to the Protection of Information Resources* (NIST SP 500-170), SN 003-003-02968-8, $1.75; *Computer Users' Guide to the Protection of Information Resources* (NIST SP 500-171), SN 003-003-02970-0, $1; and *Computer Security Training Guidelines* (NIST SP 500-172), SN 003-003-02975-1, $2.50.

The first three guides also are available through the NIST Computer Security Electronic Bulletin Board by dialing 301/948-5717 or 5718 from a terminal which has the following capabilities: ASCII; 300, 1200, or 2400 baud; 8 or 7 bits; even or no parity; 1 stop bit. After "CONNECT," strike the carriage return twice and the system will be accessed. NIST is encouraging organizations to reproduce and widely distribute all four guides.

poses, how to use technical controls, how to monitor their systems and software for abnormal activity, and what to do to contain a problem or recover from an attack. "An educated user is the best defense most organizations have," he says.

A number of commercial organizations sell software or services that may help detect or remove some types of viruses. But, says Steinauer, there are many types of viruses, and new ones can appear at any time. "No product can guarantee to identify all viruses," he adds.

To help deal with various types of computer security threats, including malicious software, NIST and others are forming a network of computer security response and information centers. These centers are being modeled after the SEI's Computer Emergency Response Team Coordination Center, often called CERT, established by the Defense Advanced Research

Educating users is one of the best, most cost-effective steps to take.

Projects Agency (DARPA). The centers will serve as sources of information and guidance on viruses and related threats and will respond to computer security incidents.

NIST develops security standards for federal agencies and security guidelines for unclassified computer systems. NCSC, a component of the National Security Agency, develops guidelines for protecting classified (national security) systems. SEI, a research organization funded by DARPA, is located at Carnegie Mellon University in Pittsburgh.

In addition, NIST recently has issued guidelines for controlling viruses in various computer environments including personal computers and networks. *Computer Viruses and Related Threats: A Management Guide* (NIST Special Publication 500-166) is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-02955-6 for $2.50 prepaid.

by Jan Kosko
NIST Public Affairs Specialist

Performance of Steels Exposed to Fire Predicted

How will structural steel behave during and after a fire? A new equation developed by scientists at the National Institute of Standards and Technology provides designers and engineers for the first time with a way to find quickly many of the answers to this complex question. The new equation can be used to assess the damage to a steel structure exposed to fire, and it can provide information for the design of new structures to improve fire performance.

The equation for predicting the performance of structural steel during and after a fire was developed by guest scientist and physicist Anne Fields, working with her husband, NIST metallurgist Richard Fields.

Designed for use on personal computers, the new equation predicts the performance of ASTM A36 structural steel when it is exposed to fire for periods from 2 minutes to 8 hours over a temperature range from 350 to 650 °C. This is the range of primary interest to structural engineers and others concerned with property loss and life safety. A36 is the most commonly used steel in the United States for buildings, bridges, and ships, as well as for other structures that are fabricated with rivets, bolts, and welds.

Even though steel is a noncombustible material, it can bend, twist, and change shape when it is exposed to intense heat. Deformation can continue after a fire as the metal cools.

Anne Fields explains that an assessment of the deformation of structural steel requires an analysis of the various stresses, temperatures, and times involved in order to calculate the resulting strains. Different types of strain are dominant under various conditions.

The strains that must be considered include elastic, recoverable strains (the steel deforms due to stress, but after the stress is removed the material regains its shape); plastic, time-independent strains (the steel changes shape or size permanently when the stress exceeds a particular value); and creep, time-dependent strains (caused by continuous stress over a period of time at elevated temperatures). In general, the higher the temperature, stress, or time, the greater the damage. Each type of strain has its own formula in the Fields' equation.

Even though steel is a noncombustible material, it can bend, twist, and change shape when it is exposed to intense heat.

The scientists developed the equation after investigating the results of available tests on structural steel. They found that the two most important sets of data on deformation behavior were for Australian AS A149 and Japanese SS41 structural steels. These steels were found to be a close fit to the ASTM A36 specification.

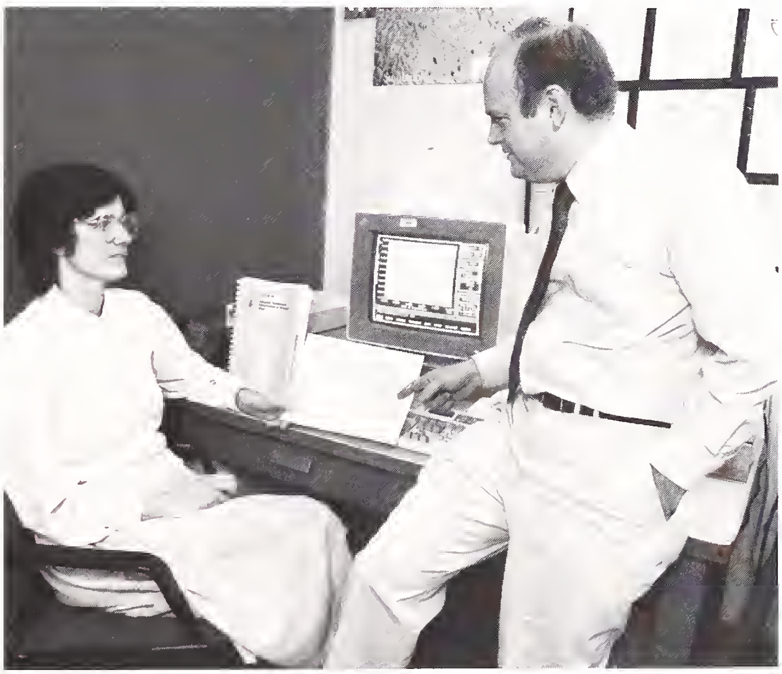
. . . an assessment of the deformation of structural steel requires an analysis of the various stresses, temperatures, and times involved. . . .

An analysis of the foreign databases by Anne Fields provided behavioral information that was lacking in the ASTM specification, which contains data on only yield stress. This is the lowest stress a steel can withstand before it becomes plastic and begins to deform. To develop the new equation, information was required on the stress-strain behavior at various temperatures and times.

The new equation also has been used to construct "deformation mechanism" maps to illustrate the dominant behavior of steel at any given temperature, time, and stress. Such maps can be used to compare the performance of ASTM A36 structural steel with foreign materials. This information could be very helpful to U.S. steel exporters and contractors in foreign markets.

The NIST research was sponsored by the American Iron and Steel Institute (AISI). AISI is a national organization of more than 50 industrial manufacturers and more than 1,300 individual members from various sectors of the steel industry.

A report, *Elevated Temperature Deformation of Structural Steel* (NISTIR 88-3899), with the new equation and information on the correlations between measured and predicted strains for ASTM A36, Australian AS A149, and Japanese SS41 structural steels, is available prepaid for $21.95 from the National Technical Information Service, Springfield, VA 22161. Order by PB #89-172621/AS. *R.R.*



Guest scientist Anne Fields and NIST metallurgist Richard Fields discuss a deformation mechanism map, which illustrates the dominant behavior of steel at a given temperature, time, and stress.

Model To Fight Fire Deaths, Costs

The National Institute of Standards and Technology has released HAZARD I, a unique analysis method and computer program that promises to revolutionize fire-safety practices and lead to marked reductions in fire losses and costs. The culmination of 6 years of development by the NIST Center for Fire Research, it is the first such comprehensive use of fire modeling in the world.

"HAZARD I represents the tremendous strides that have been made in measuring fire hazard and safety. We're hoping it launches a revolution in how fire is thought about, planned for, and confronted," says Jack Snell, director of the NIST center.

Each year, fires in the United States cost nearly 6,000 lives, nearly 90,000 injuries, and billions of dollars in direct property damage—one of the worst fire-loss records in the industrialized world. The total cost in the United States of fire losses and fire protection is nearly $50 billion a year.

HAZARD I can be used on a personal computer to predict the hazards to occupants in a burning building and the change in hazard that will result if certain products, such as furniture, are changed in design or composition. "The user picks the building, the fire, the object burning, and the people in the building, and the computer does the rest," says Richard Bukowski, manager for technology transfer in the center, who has led the program's development.

The software predicts the temperature and smoke and toxic gas concentrations in each room of the building as well as the behavior and movement of the building occupants and the ultimate outcome of the fire. "The program predicts who will be able to escape, who will become incapacitated and who will die. If it predicts someone will die, HAZARD I can determine where the person will die and from what," says Bukowski. "This information should provide better, more cost-effective strategies for reducing fire losses," he adds.

HAZARD I incorporates the results of fire research conducted over the past 15 years at NIST and elsewhere. It is the first computer model to take into account the complex combination of physics, chemistry, fluid mechanics, heat transfer, biology, toxicology, and human behavior that determines the outcome of a fire.

To help transfer this new technology to the fire protection community, NIST is working with several organizations. For example, the National Fire Protection Association (NFPA) has agreed to distribute the HAZARD I package. NFPA is a private, nonprofit organization of more than 52,000 members and is the nation's principal source of voluntary consensus fire codes and standards. "NFPA sees HAZARD I as an important new tool that may have great use in protecting people and their property from fire, which is the mission of NFPA," says Robert Grant, NFPA president.

In addition, Bukowski is working with the Center for Firesafety Studies at Worcester Polytechnic Institute to develop training programs to help users become familiar with HAZARD I.

Bukowski sees HAZARD I being used in a variety of ways in fields ranging from fire investigation and reconstruction to fire protection engineering to product development, manufacturing, marketing, and architectural design.

He hopes that one of the major uses of HAZARD I will be to help code developers like NFPA and building and fire code officials deal more easily with new materials or design and construction techniques. Fire safety in the United States is enforced through state and local codes intended to provide time for people to evacuate safely. "Time is the critical factor," says Bukowski. "Having 3 minutes for safe escape when 10 are needed results in disaster. But providing 30 minutes of protection when 10 are needed can lead to higher construction and operating costs."

The codes have not been able to address directly these comparisons between time required for escape and time available for escape because no model or other source of sound information has been available to make the necessary calculations. The experts who develop codes have had to rely upon more limited sources, such as test methods that examine specific fire properties or performance characteristics of a product. They used their own judgment to fill in any gaps. Because no model existed to show how these different characteristics combined in a real fire, code developers had to determine acceptable safety margins for each product characteristic.

With HAZARD I, code developers can see how a product's characteristics affect a fire. And, they can see how modifying the product will change not only the results of laboratory tests but also the critical time available for escape by building occupants.

"NFPA sees HAZARD I as an important new tool that may have great use in protecting people and their property from fire. . . ."

The need still exists for expert judgment in using the model and interpreting its results, but the codes developers and codes officials will have much more help with HAZARD I.

By realistically estimating product performance, HAZARD I also should permit the codes to be adjusted more easily to new materials, designs, products, and technology. A nontraditional fire-safe product may have its performance "proven" on the computer. "With a tool like HAZARD I, new technology can be evaluated cost-effectively and its likely impact on fire safety can be determined before a performance record is established through use," says Bukowski.

Bukowski envisions an even broader range of uses in the future, including training firefighters or planning how to fight a fire in a particular building. HAZARD I also could be used by educators to teach children about fire safety and homeowners to plan escape routes and make their homes more fire-safe.

While some studies to validate the models and procedures have been conducted and the system has been tested by NIST and outside groups, Bukowski cautions that it is a prototype and does have limitations. HAZARD I can be used reliably to model up to six rooms in a building similar in size and construction to a single-family residence. However, not enough is known yet about how smoke and toxic gases move through heating, ventilating, and air-conditioning (HVAC) systems and tall shafts and stairways to model larger buildings. "In a fire, a building's HVAC system may distribute fire products to some parts of the building faster than the fire alone would," says Bukowski. However, other NIST researchers are studying smoke movement by HVAC systems. This data will be included in a future version of HAZARD I and will allow modeling of multi-story occupancies.

"This is just the beginning for HAZARD I," says Bukowski. "As the research continues and we get more data, we'll continue to revise and refine the program," he adds.

A three-volume report and a set of computer disks containing the software necessary to conduct a hazard analysis are available for $225 from the National Fire Protection Association, One Stop Data Shop, Batterymarch Park, Quincy, MA 02269 or the National Technical Information Service, Springfield, VA 22161. Use order number PB 89-215404 when ordering from NTIS. *J.K.*

Data, Anyone?

esearchers at General Dynamics Corp. faced a problem: They needed to know how certain materials would perform as shielding on the outside of spacecraft such as the shuttle. In particular, these researchers were investigating how a substance known as amorphous carbon would act under the tremendous heat spacecraft are exposed to upon re-entering the atmosphere. At what temperature would the material evaporate? To help solve the problem, the General Dynamics researchers called on NIST's Standard Reference Data (SRD) program.

Various researchers had published data on the thermodynamic properties of amorphous carbon at more earthly temperatures, while others had published more complete tables for carbon in the form of graphite. SRD experts investigating the situation discovered that at high temperatures, amorphous carbon acted enough like graphite that the General Dynamics researchers could use the published graphite data for their study.

In another example, researchers at the U.S. Army's Aberdeen Proving Ground enlisted the help of the SRD program. The Army needed to dispose of batches of a hazardous warfare chemical called Lewisite. They wanted to burn it but they had no idea how much heat the dangerous chemical would give off. Would it explode? The Army researchers got the information they needed from SRD experts to safely burn the unwanted chemical.

In many such cases, the NIST Standard Reference Data program supplies data to scientists and engineers in industry, academia, and the military. SRD experts often advise researchers faced with incomplete, questionable, confusing, or conflicting data.

Over the years scientists have disseminated stacks of tables and lists of values ranging from the heat capacity of liquid helium to the fracture toughness of aluminum alloys.

> **"We go out to find what data will help improve industries' competitiveness down the road. . . ."**

SRD experts cull the most reliable data from the published literature. Top-rate specialists assess the stock of existing data and skim from it manageable, trustworthy lists of figures—values industrial technologists need for particular applications.

Researchers from the SRD program keep up on the latest trends in data. The staff confer with industry representatives to decide which data will be needed for the coming months. As technology changes, industries may come to require new figures for the radiation levels from nuclear waste products, the atmospheric reactions of ozone-layer safe refrigerants, or the burning power of alcohol-based fuels. "We go out to find what data will help improve industries' competitiveness down the road," says Malcolm Chase, acting chief of the NIST SRD program.

Once they set out to produce a needed set of data, SRD experts must "critically evaluate" existing data on the topic. To do this, they check the methods the original scientists used to obtain their figures and test how well trends in the data follow known physical and chemical laws.

Much of this data assessment goes on in approximately 20 data centers, where groups predominantly made up of NIST scientists work on 3- to 7-year projects producing data with broad applications. In addition, NIST scientists join with industry and university researchers on shorter term, 1- to 3-year data projects fulfilling more specific data needs.

All the studying and sorting done through these data centers and data projects culminate in either journal articles or computerized databases. Because the SRD program caters to a variety of customers, the researchers must create a product that people without specific expertise can use easily. SRD experts package their data either as clearly documented journal entries or in user-friendly software databases that customers can read on a personal computer.

Some of these databases simply allow the user to search through large volumes of data. One lists 39 properties of the 1,023 most important industrial chemicals. Other databases actually calculate desired values. In the database called MIPROPS, a user might, for instance, punch in pressure and temperature for a substance, say a hydrocarbon, and receive information on density, viscosity, and other key properties.

The SRD program provides data in three major areas: physics, chemistry, and materials. Much of the physics data help scientists doing spectroscopy—the identification of atoms or molecules according to the frequencies of light they emit. An energized atom or molecule gives off its own unique spectrum of frequencies as its electrons make jumps in energy, which return the atom or molecule to an unenergized state. Scientists use spectroscopy to determine the compositions of high-temperature plasmas—ionized gases that make up stars as well as the starting materials for nuclear fusion. For such studies, scientists need tables listing which frequencies identify with which atoms and molecules.

Research chemist W. Gary Mallard (left) and John Herron, head of the NIST chemical kinetics data center, demonstrate the chemical kinetics database.

Other physics data describe how much energy x rays and gamma rays lose when passing through various materials and how different elements react chemically when their electrons are boosted to excited energy states. Applications range from designing radiation shielding for medical equipment to monitoring acid rain.

The chemistry data centers supply data on the properties of chemicals—how they melt, vaporize, and dissolve in various fluids. Chemical data also describe how different chemicals react—how readily they react, how fast, what products form, how much energy is needed to fuel the reaction, and how much heat is released. In addition, the same spectroscopy data used by physicists help chemists analyze the composition of materials.

Data on metals, ceramics, and polymers are furnished by researchers in the materials data centers. The SRD program provides computer databases and published tables describing how these materials bend, break, corrode, melt, and mix together. SRD scientists work with researchers from industrial societies, such as the American Ceramics Society and the National Association of Corrosion Engineers, as well as government agencies, including the Department of Energy and the National Science Foundation. Together they undertake cooperative data programs of special interest to industries. *F.F.*

New Publications

International Cooperation and Competition in Materials Science and Engineering

Schwartz, L.H. and Schneider, S.J., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4041, 277 pages (June 1989). Order by sending a self-addressed mailing label to Samuel Schneider, NIST, B309 Materials Bldg., Gaithersburg, MD 20899.

Materials experts from industry, universities, and government argue in a new report that the national programs of other nations in technology development, related to materials science and engineering, have made Europe and Japan fully competitive and, in some cases, able to surpass the United States. The study on national comparisons was conducted by Panel 3 of the Committee on Materials Science and Engineering commissioned by the National Research Council. The report by Panel 3, led by Lyle Schwartz, director of the NIST Materials Science and Engineering Laboratory, deals with many facets of materials science and engineering as practiced in the United States and other countries. It contains information from a survey of national programs for science and technology and materials science and engineering, and it elaborates on the administrative structures to carry out research and development.

Electronic Publishing: Guide to Selection

Rosenthal, L.S., Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 500-164, 37 pages (June 1989). Order by stock no. 003-003-02938-6 from GPO, $2.50 prepaid.

Electronic publishing offers many pluses when it comes to producing documents and publications: reduced costs, increased productivity, and improved document quality. But these potential benefits can be realized only if the system chosen is appropriate for the organization and is installed and managed properly. NIST researchers have developed guidelines to help managers and users make informed decisions on which systems are best for them. The guide is designed to acquaint the reader with the many choices and implications associated with selecting and using electronic publishing systems.

Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

Oppermann, H.V., editor, Natl. Inst. Stand. & Tech. (U.S.), NIST Hdbk. 44-1990, 275 pages (September 1989). Order by stock no. 003-003-02964-5 from GPO, $16 prepaid.

This handbook has been revised by NIST to reflect changes adopted at the 74th Annual Meeting of the National Conference on Weights and Measures (NCWM) held in July 1989. NCWM is an organization of state, county, and city weights and measures enforcement officials, which was established in 1905. NIST, which is a non-regulatory agency, provides technical support to NCWM through its Office of Weights and Measures.

The major changes in this handbook include a revised section on liquid measuring devices that establishes a requirement for equipment capable of computing the cash/credit pricing of retail motor fuel. NCWM also adopted a specification permitting the use of electronic data audit trails as security seals for electronic devices that are to be considered the equivalent to the physical sealing of other devices with lead and wire seals or pressure-sensitive seals.

Uniform Laws and Regulations

Brickenkamp, C.S. and Koenig, J., editors, Natl. Inst. Stand. & Tech. (U.S.), NIST Hdbk. 130-1990, 172 pages (October 1989). Order by stock no. 003-003-02962-9 from GPO, $10 prepaid.

This handbook was revised by NIST to reflect changes made at the 74th Annual Meeting of the National Conference on Weights and Measures. A new regulation was adopted for the maximum allowable variation (MAV) for polyethylene sheeting. Individual packages of poly sheeting cannot be short weight or short in thickness by more than an MAV of 4 percent of the labeled weight or thickness. There also is a revision to the Uniform Regulation for the Method of Sale of Commodities that covers stuffed items such as meat, fish, seafood, and poultry as combination foods. The quantity representation may be in terms of the total weight of the product or combination, and a quantity representation need not be made for each element provided that a list of the ingredients in order of their predominance by weight is shown on the label. The handbook also contains a new method of sale requirement for home liquid oxygen used for respiration.

Materials Science and Engineering Laboratory

Natl. Inst. Stand. & Tech. (U.S.), 24 pages (August 1989). Order by sending a self-addressed mailing label to the Materials Science and Engineering Laboratory, NIST, B309 Materials Bldg., Gaithersburg, MD 20899.

Scientists in the NIST Materials Science and Engineering Laboratory are investigating the relationship between the structures and properties of materials, then applying the information to problems related to the design, processing, and performance of advanced ceramics, polymers, and metals. The research is focused on improving the understanding of materials processing to meet the needs of U.S. industry. In the area of automated process control, the goal is to help industry develop real-time, automated systems for the intelligent processing of materials that emphasize product quality throughout the manufacturing process, rather than at the end of the line.

Guideline for Work Station Design

Rubin, A. and Gillette, G., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4163, 151 pages (September 1989). Order by sending a self-addressed mailing label to Arthur Rubin, NIST, A309 Building Research Bldg., Gaithersburg, MD 20899.

The computerized work station often is considered the key to increased office productivity. Yet, work station furnishings and layout seldom are given the same attention and resources as the technology. To help managers make intelligent choices, NIST researchers have developed a process for designing work stations based on office activities, including reading and writing, talking on the telephone, drafting and drawing, or using a video display terminal. Work station dimensions and configurations then are developed depending on the importance of the activity and the time spent on it.

Service Life of Concrete

Clifton, J.R. and Knab, L.I., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4086, 151 pages (June 1989). Order by stock no. PB 89-215362/AS from NTIS, $21.95 prepaid.

In a study for the U.S. Nuclear Regulatory Commission (NRC), NIST researchers are attempting to determine if concrete can be formulated to last up to 500 years. The NRC is responsible for developing a strategy for storing low-level radioactive waste. One approach being considered by NRC involves storing radioactive wastes in underground concrete vaults that will be required to last 500 years. NIST researchers analyzed the major degradation processes likely to affect the vaults and recommended ways to predict the service life of concrete. Based on available knowledge, they concluded it seems likely that concrete can be formulated which should have a service life of 500 years in the expected environments. NIST cautions that such a lifetime can be achieved only if the concrete materials meet carefully defined specifications and good construction practices are followed.

Sensors and Measurement Techniques for Assessing Structural Performance—Proceedings of an International Workshop

Marshall, R.D., editor, Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4153, 66 pages (August 1989). Order by stock no. PB 89-235865 from NTIS, $15.95 prepaid.

Reliable, economical devices are needed to measure the behavior of structures during events such as earthquakes or strong winds or to assess the day-to-day condition of a structure. At present, field measuring devices tend to be costly and need almost constant monitoring as well as frequent equipment servicing and calibration. In some cases, they produce questionable data or malfunction during critical events such as earthquakes. In a meeting held last fall, experts from around the world convened at NIST to discuss these problems and some new materials and improved technology that could have a dramatic impact on the reliability and versatility of measurement devices. In addition, the experts formulated recommendations for future research.

False Alarm Study of Smoke Detectors in Department of Veterans Affairs Medical Centers

Dubivsky, P.M. and Bukowski, R.W., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4077, 234 pages (May 1989). Order by stock no. PB 89-193304/AS from NTIS, $15.95 prepaid.

Over the past few years, the problem of false alarms from smoke detectors has been growing in large buildings, such as health care facilities. NIST and Underwriters Laboratories, Inc., recently studied smoke detector false alarms in 133 Department of Veterans Affairs Medical Centers (VAMC's). The researchers determined that two principal factors play a major role in the rate of false alarms: the design and sensitivity of the detector and the testing, cleaning, and operational procedures at the VAMC's. They found that the ratio of false alarms to real alarms was about 16 to 1 and that about half of the total number of false alarms is related to smoking. Among the numerous recommendations, the one that should have the greatest impact say the researchers, is strictly enforcing policies regarding designated smoking areas.

Ordering Information

To order publications from NTIS, send request with payment to: National Technical Information Service, Springfield, VA 22161. Publications can be ordered from GPO by mailing the order with payment to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Conference Calendar

Workshop on Electrical Measurement Assurance Programs

Inn at the Airport, Tucson, AZ

This workshop will provide in-depth training for those involved in d.c. and low-frequency electrical measurements. Participants will receive instruction based on calibration design methods and statistical quality control techniques used at NIST. Participants will learn how to establish and maintain rigorous quality control programs in their own laboratories to ensure the accuracy of electrical measurements. Sponsored by NIST. Contact: Joe Simmons, NIST, B360 Physics Bldg., Gaithersburg, MD 20899, 301/975-2002.

International Conference on CIM Architecture (CIMCON '90)

NIST, Gaithersburg, MD

Much has been learned from the initial implementation phases of early computer-integrated manufacturing (CIM) programs. CIMCON '90 will provide a forum for people to describe their original architectures and implementation plans, to discuss what did and did not work, and to report on changes they might be considering in those architectures and plans. This conference will give those responsible for CIM architecture the opportunity to discuss standards needs with experts from around the world and to learn about the problems involved in integrating new and existing manufacturing systems. Sponsored by NIST, the Navy Manufacturing Technology Program, the U.S. Air Force WRDC/MTI, and the University of North Carolina at Charlotte. Contact: Albert Jones, NIST, B124 Metrology Bldg., Gaithersburg, MD 20899, 301/975-3554.

Fiftieth Annual Conference on Physical Electronics

NIST, Gaithersburg, MD

The physics and chemistry of solid surfaces and interfaces will be addressed at this conference. Topics will include electronic, chemical, and crystallographic properties of surfaces and interfaces as well as kinetic and dynamic mechanisms of physical and chemical reactions, phase transitions, and adsorption. The properties of surfaces that are clean or that incorporate foreign atoms are also of interest, as are new methods of surface analysis and characterization. Emphasis will be placed on the description of surface and interface properties at a fundamental atomic and molecular level. Sponsored by the American Physical Society, NIST, and the University of Maryland. Contact: Richard Cavanagh, NIST, B248 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-2368.

Conference on Advances in Cementitious Materials

NIST, Gaithersburg, MD

This conference will be of interest to all concerned with enhancing the performance of concrete and making it a more predictable material. The purpose is to advance understanding of cementitious materials to provide a rational approach to the design of new cementitious materials and composites. The fundamental science underlying the behavior of all cementitious materials will be addressed; however, to limit the scope of the conference, degradation processes will not be included. Session topics include characterization of particulate starting materials and of resultant microstructure; physical and chemical phenomena in the flow of cementitious materials prior to hardening; relationships between microstructure and physical and mechanical behavior; interactions of water with the hardened cement paste matrix; and the microstructure and micromechanics of cementitious composites. Participants will be able to visit the laboratories of the NIST Center for Building Technology. Sponsored by NIST and the American Ceramic Society. Contact: Geoffrey Frohnsdorff, NIST, B368 Building Research Bldg., Gaithersburg, MD 20899, 301/975-6706.

International Conference on the Chemistry of Electronic Ceramic Materials

Grand Teton National Park, WY

Materials chemistry has evolved from the more identifiable disciplines of inorganic and solid state chemistry, ceramics, and materials science. This conference will bring together major national and international researchers to bridge the gap between those primarily interested in the pure chemistry of inorganic solids and those interested in the physical and electronic properties of ceramics. One of the primary goals of the conference will be to evaluate the current understanding of the chemistry of electronic ceramic materials and to assess the state of a field that has become one of the most important areas of advanced materials research. Sponsored by NIST, the Office of Naval Research, and federal, university, and industry scientific organizations. Contact: Robert Roth, NIST, B126 Materials Bldg., Gaithersburg, MD 20899, 301/975-6116.

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