A 21st-Century Chemistry Lab

The new Advanced Chemical Sciences Laboratory (ACSL) at the National Institute of Standards and Technology in Gaithersburg, Md., was built to house research programs that establish and ensure accuracy for millions of chemical measurements made in the United States.

The $75 million, 18,588 square-meter (200,000 square-foot) building is a state-of-the-art research facility with advanced features that will allow NIST scientists to extend their capabilities and increase the efficiency and impact of their world-class research in biotechnology, analytical, environmental, clinical, and other related chemical measurements and standards in a safer, more healthful work setting.

Source: The Austin Company, Designer-Builder

Laboratories in the ACSL feature modular design, improved lighting and ventilation, and utility services run along high ceilings, freeing more lab bench space for experiments.

Building materials and equipment selected for the new building were chosen carefully. For example, fume hoods, lab benches, and other lab equipment do not contain elements that could contaminate analytical samples. NIST chemists now will be able to develop new standards for measuring extremely small quantities of elements such as lead, which is implicated in environmental and health problems. The building also features high-efficiency air handling, precise temperature and humidity control, an uninterruptible power supply, an emergency back-up generator, and a wiring backbone that will satisfy data transmission needs well into the 21st century.

In their previous laboratory facilities, NIST scientists often discarded or delayed significant numbers of chemical measurements, ranging from

10 percent to 30 percent depending on the time of year and measurement method, due to unacceptably large variations in environmental conditions. The more stable vibration, temperature, electrical power, humidity, and air quality of the ACSL is increasing the efficiency and quality of measurements by allowing longer uninterrupted measurement cycles.

Research in NIST's Chemical Science and Technology Laboratory long has benefited our nation's health and environment, as well as industrial productivity and international trade. As science and technology have advanced, the need for accurate new chemical measurements, standards, and methods has risen dramatically. The new ACSL building is providing the means to meet 21st-century needs for pharmaceutical manufacturing, medical diagnostics, pollution monitoring and clean-up, nutritional analysis, and more. The following examples illustrate the expected impact of research in the new ACSL.

Biotechnology

Today, DNA technology is being used far beyond the courtroom. One rapidly growing application is in clinical laboratories. The ability to analyze the genetic sequence encoded in the DNA of many disease-causing microorganisms is quickly bringing about many new diagnostic tests based on DNA analysis. The new ACSL will give researchers the necessary levels of air cleanliness and temperature control to develop advanced

To produce new DNA standards, NIST researcher Catherine O'Connell is investigating methods to measure genetic mutations that can result in cancer and other diseases.

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measurement methods and standards for the emerging DNA diagnostics industry. NIST standards for DNA diagnostics will help to benchmark and ensure the accuracy of new tests for bacterial and viral diseases and even genetic diseases and cancer, in much the same way previous NIST standards have led to more accurate clinical tests for cholesterol, various elements in blood, and other markers of human health.

When the NIST Chemistry Building was built in the 1960s, its designers could not have anticipated laboratory space requirements for molecular biology in the 1990s and beyond. For the first time since its formation in the late 1980s, the NIST Biotechnology Division has facilities designed to fully meet the contamination and temperature control standards set by the FBI's DNA Advisory Board for labs performing DNA analysis.

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Here, chemist Robert Vocke is making careful measurements of lead as part of work on Standard Reference Materials for clinical labs and building inspectors.

Given new state-of-the-art facilities, the NIST Biotechnology Division is expanding its capabilities in emerging areas of biotechnology, such as tissue engineering, flow cytometry, and metabolic engineering, all of which could improve diagnosis and treatment of disease. Current efforts to develop standards and measurement methods in these areas have been hampered by the lack of sufficient air cleanliness and reliable temperature control in the older laboratories.

Ultratrace Chemical Analysis

Chemists cannot determine an element in concentrations that are lower than the background levels of the element in the laboratory. The biggest benefit of the new ACSL to NIST analytical chemists is the ability to analyze much lower levels of elements and compounds in a given sample than was possible in the old Chemistry Building. Specific examples follow.

Source: The Austin Company, Designer-Builder

To prevent sample contamination, five non-metallic labs were designed for trace metals research. The few metal components that were required were coated with epoxy sealant.

Advanced Materials. Ultratrace analysis is important in the development of new, more reliable advanced materials for industry. The development of aircraft turbine blade materials with low levels of sulfur is an example. NIST is making measurements of sulfur in superalloys that are used in jet-engine turbines because the level of sulfur affects the useful life of the jet turbine blades (more sulfur = weaker, less durable material). According to metallurgists, a sulfur content of greater than one part per million adversely affects engine performance. With the cleaner environment in the ACSL, NIST will be able to provide the measurements and standards required to assist U.S. industry in solving difficult technological problems.

Health. Scientists have found that adverse health effects are caused by certain chemicals at extremely low concentration levels. In order to accurately ascertain the concentration of such chemicals and to get reliable and comparable results from different labs, measurement standards are necessary. For instance, the new laboratory facilities are allowing chemists to develop measurement standards for nickel in blood serum, impossible to do previously.

Environmental Monitoring. The new laboratory is enabling NIST to make measurements and to

develop better standards to benchmark environmental pollutants, such as lead and cadmium in a wide variety of sediments, soils, water, and tissue samples.

Measuring Complex Compounds

In recent years, an array of new analytical instrumentation and techniques have become available to help chemists accurately measure complex chemical compounds in complex samples, such as living tissues, sediment and soil, and foods. These instruments and techniques require the improved temperature, humidity, and electric power control, along with the clean air supply, of the ACSL.

Environmental Analysis. Previously, contaminants in the Chemistry Building's air-handling system limited the analysis of low levels of dioxins, pesticides, and other toxic contaminants. NIST expects a factor of two or better improvement in sensitivity to trace organic toxins due to the improved environment of the ACSL. This enhanced sensitivity will allow NIST to detect and measure organic toxins at previously unattainable levels in complex materials such as human serum, animal tissue, and marine tissues and sediments.

Health Measurements. As medical researchers

NIST chemists Jeanice Brown Thomas and Katherine Sharpless are developing Standard Reference Materials for the food processing industry to ensure accuracy in food nutrition labeling.

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NIST chemists, including Pamela Chu, have created a database of chemical signatures of airborne pollutants that is used in air-quality monitoring.

discover that the levels of various proteins in the body are early indicators of cancer (e.g., prostate specific antigen) or heart attack (e.g., cardiac troponin I), they need new measurement methods and standards for assessing these complex molecules. The ACSL's improved air and power quality are helping NIST chemists to make accurate measurements of these proteins at very low levels.

Nutritional Analysis. To meet FDA regulations on nutrition labeling, as well as to certify that U.S.-produced food products meet international standards, food manufacturers need highly accurate measurement standards for an ever lengthening list of vitamins, fats, proteins, carbohydrates, and other nutrients, as well as contaminants in food. To meet the demand for such measurement standards, NIST chemists are relying on the improved air cleanliness, humidity control, and reliable power supply of the ACSL.

Pharmaceuticals. Few would know, but when you take prescription medicines, you can rest assured of their quality in part due to a small rectangular filter, about the size of a stick of lip balm. NIST chemists make batches of these optical filters for calibrating an analytical instrument known as a spectrophotometer. Drug manufacturers use spectrophotometers calibrated with NIST standards to check the concentration of a drug in a pill as well as to determine how fast a particular pill dissolves. Temperature and humidity control problems have plagued the production of these standards for years, resulting in a steadily growing waiting list. The ACSL gives NIST a much cleaner and more efficient environment for making the filters.

Special ACSL Features

- 18,588 square-meter, or 200,000 square-foot, building
- 162 laboratory modules with movable walls
- Temperature controlled to ±0.5 °C
- Humidity maintained at 40 percent, ±5 percent
- High-purity, recirculating laboratory water system
- Building-wide uninterruptible power system
- Service galley between back-to-back labs for improved safety, optimal use of lab space, and ease of maintenance
- Five class 1000 clean rooms
- Five non-metallic laboratories
- Two cold rooms (4 °C) for biotechnology research
- High ceilings (4.3 m) for lab flexibility and ease of maintenance
- High-velocity ventilation systems
- Perchloric acid hoods with integral washdown system
- Storage areas for SRM gas cylinder inventory

For more information on NIST's Advanced Chemical Sciences Laboratory, call William F. Koch at 301-975-3146.

Source: The Austin Company, Designer-Builder

Pure water, essential to all chemical analysis, is provided by a state-of-the-art, computer-controlled deionization/purification recirculating system.

Cover photo:
Advanced Chemical Sciences Laboratory
Source:
The Austin Company,
Designer-Builder

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