Science Labs Change with the Times

Sophisticated Equipment, Advancing Technology Impact 21st-Century Labs

The current decade proves that, just as science itself evolves, science laboratories must adapt, expand, and transform to accommodate the experiments and instrumentation that is required to do that science.

Significant advancements in nearly every scientific field, along with massive technological innovations, create the need for labs with features scientists only imagined 10 or 20 years ago, says Dr. Richard Rietz, an independent strategic lab planner based in Helena, Mont. Before 1990, he explains, labs changed incrementally. Retrofitting was easier because the development of scientific tools and new experiments occurred at a slower place within each particular discipline. Therefore, following a "traditional" model for lab design was logical: biology labs for biologists, chemistry labs for chemists, computer labs for computer scientists.

Now, most scientific disciplines are overlapping and relatively new science fields, such as bioinformatics and nanotechnology, are becoming major players. This creates a need for multi-disciplinary buildings where scientists of all kinds work together, as well as buildings that can support the new tools and techniques, Rietz explains.

At the same time, equipment within labs is more specialized, sensitive, and more expensive than ever before, making lab design and development a complicated endeavor —with a long list of factors and challenges to consider.

Rietz, who spoke in May at Tradeline's *Research Buildings 2006* conference, defines several of these factors and the impact they have on today's laboratories.

Localized Cleanrooms

First, as analytical equipment becomes more sophisticated, with the ability to make measurements that used to stay below the detection threshold, the need for cleanrooms that protect individual instruments and experiments is growing.

"We can now analyze at a much finer level," Rietz says, explaining that most older cleanrooms were not designed for just one piece of equipment or only one experiment.

Building brand-new whole building cleanrooms is costly, and many institutions simply don't have money in the budget for such an expense. Instead, they retrofit existing laboratories' cleanrooms. Sometimes this is as straightforward as installing high-efficiency particulate air filtration systems or separating the space with polyethylene curtains.

"The idea is to get a small amount of a very clean space, not to build a whole new cleanroom," Rietz says.

The geosciences laboratory at Boise State University in Boise, Idaho, where scientists analyze lead isotopes and determine the ages of various geological formations, serves as an example. As a trace metals lab, even a hint of metal in the environment will interfere with the accuracy of experiments. A cleanroom, therefore, is a must. But the existing space didn't meet these specs and building a new cleanroom proved too costly. Instead the university retrofitted an existing space, creating a metal-free cleanroom that meets the lab's very specific requirements.

Cart Laboratories

The ever-increasing use of chromatography for separations as well as the affordability of analytical instrumentation gives rise to the second driving force: labs full of instrumentation on carts.

"You can roll the instruments around," says Rietz. "The whole cart pulls away from its primary location so you can move it from one lab to another."

Utilities provided from an overhead service carrier are easily disconnected and reconnected in a new location, he adds.

This gives scientists flexibility they didn't enjoy before, Rietz explains, because they can just take their instruments with them if they need to set up a new lab or reconfigure the work flow in an existing lab. Carts also provide access to the back side of the equipment, allowing scientists to make the most of the space they have; equipment housed in a fixed lab might be up against a wall, with no way to get around to the back.

A stellar example, Rietz says, is the Biodesign Institute at Arizona State University. Named *R&D Magazine*'s 2006 Lab of the Year, the facility uses cart labs almost exclusively.

Chilled Beams

Labs full of instrumentation do have a downside, however: they generate a lot of heat. An uncomfortable work environment or overheated instrumentation is the result, and the obvious solutions—fans and air conditioning—use a lot of energy and money. Enter chilled beams, a water-filled cooling device that is either suspended from the ceiling or integrated into the ceiling itself. Chilled beams cool rooms via a convection-like process: the heat in the room rises and the water-filled beams cool said air, either through an active process (a fan blows the air back into the room) or a passive process (the air just descends on its own).

Several organizations in the United Kingdom, such as Trust Sanger Institute in Cambridge, already use chilled beams. In the United States the concept is just starting to gain recognition, and one Pacific Northwest biomedical lab is currently incorporating chilled beams into the design of its new facility. Rietz anticipates the use of chilled beams in the United States to really take off, perhaps by the end of the decade.

High-Performance Embedded Subspaces

Practically the polar opposite of a cart lab, high-performance embedded subspaces are the result of the next force on the list: the increasing use of large, expensive machines such as a high resolution electron microscopes, atomic resolution tools, and high-field spectrometers.

"These machines achieve very high resolutions," says Rietz. "But all need specialized environments to work properly. They are finicky and they only work when everything around is perfect. The air has to be perfect, and there can be no vibration and no magnetic or radiofrequency interference."

Most lab buildings were not designed with these machines in mind, but the need for space to accommodate them is growing.

"A lot of science is relying on these tools," he adds.

But many science buildings are already crowded and just don't have room. Boston College solved this problem by creating a subspace for a scanning transmission electron microscope in the basement of a science building—a process that involved digging several feet below the building's foundation. Some institutions do manage to find space to build rooms within existing rooms, Rietz said. In any scenario, however, the key is making sure the space has low vibration, low electromagnetic interference, and proper acoustics.

Core Laboratories

Fifteen years ago, the machines in what Rietz now refers to as core labs were more like the machines in embedded subspaces today—expensive and exclusive, requiring all users to have specialized training and knowledge. Now, these machines (nuclear magnetic resonance or transmission electron microscopes, for example) are fairly standard. Many scientists know how to use them and most institutions allow user access to them because they are relatively affordable (prices have dropped from millions to hundreds of thousands). A core lab functions as a shared space for the machines and the scientists who use then. At John Hopkins University in Baltimore, for example, a core lab houses multiple NMRs that many users can access.

Work Cells

Within these labs look for work cells, small enclosed spaces that offer protection to extremely sensitive equipment. At a Johnson & Johnson research and development lab in La Jolla, Calif., for example, a 25-foot long work cell in an open lab keeps a robot enclosed. Unfortunately, Rietz says, work cells are cumbersome and difficult to work around because they take up a lot of space, use a lot of resources, and sometimes radiate a lot of heat.

Super-Computer Rooms

Even as lab equipment becomes more sophisticated, some science is actually moving out of the lab environment and onto the computer monitor, Rietz says, creating the need for super-computer rooms (scientists refer to this as “dry lab or “science in silicone” work). Some contain one very powerful computer; others contain multiple computers working on parallel operations (searching for gene sequences, for example).

“These computers can do lots of operations very fast, things your personal computer would just choke on,” he says.

Super-computers generate a lot of heat and often occupy a significant amount of space, requiring some institutions, such as Trust Sanger, to house the computers in a dedicated space with its own cooling system.

Social Space

Scientists spend a lot of time in front of monitors and microscopes, but they still need to collaborate with others and take the occasional break. This leads to a need for social spaces within science buildings—areas with tables and chairs, couches, even coffee carts. Most are centrally located within their respective buildings, and feature design elements that encourage people to really use the space to its fullest potential. Rietz points to the “team room” at the Avon Global Research and Development Center in Suffern, N.Y., as his favorite example. The space has an open stairwell, lots of windows, and a trendy red sofa.

“A tremendous amount of money is being spent on these spaces,” says Rietz.

Internal Vision Glass

Rather than regular walls, many modern labs are built with floor-to-ceiling windows, or internal vision glass, instead. Two forces drive this fast-growing trend, Rietz says. First, vision glass helps satisfy the need to socialize and collaborate with others — people can easily see into labs if they are looking for someone or something. Secondly, vision glass encourages safety, Rietz explains. If an injury occurs while someone is working in the lab alone, passers-by are more likely to find and help the victim. Vision glass also makes illegal activity, such as theft or terrorism, more difficult because labs can be locked but still visible. Rietz again points to the Biodesign Research Institute at ASU as an example. The building uses vision glass not only in labs, but in administrative offices and social spaces as well.

Protecting Workers and Maximizing Space

While features such as cart labs, localized cleanrooms, and social spaces are leading the pack, several others follow close behind:

- *Weigh stations*: This is just an enclosure around a scale or a power-producing experiment, Rietz explains, designed to protect personnel from fumes and toxic powders. Common in pharmaceutical labs for some time, they are now appearing in institutional and academic labs as awareness of the hazards of powder exposure grows.
- *High-bay labs*: Standard ceilings are 10-feet high, says Rietz — not tall enough for some of today's engineering and test equipment. High-bay labs reach spans as high as 30 feet, easily accommodating larger items. Look for high-bay labs in universities with environmental or civil engineering programs.
- *Dense floorplans*: Lab space is at a premium, especially in urban settings, Rietz says. This requires institutions to make the most of every inch, and many turn to open labs or overhead storage space (the University of California, San Francisco, does a particularly good job with their limited space, Rietz explains). Some even squeeze new buildings between or on top of existing structures.

Biography

An independent lab consultant based in Helena, Mont, **Richard Rietz**, holds a Ph.D. in analytical and inorganic chemistry from Indiana University. He studies the planning, management, and use of institutional, academic, and corporate laboratories, and works with major institutions and corporations in the preparation of capital plans, space strategies and facilities programming.

This report was based on a presentation by Rietz at the Tradeline *Research Buildings 2006* conference in May.

For more information

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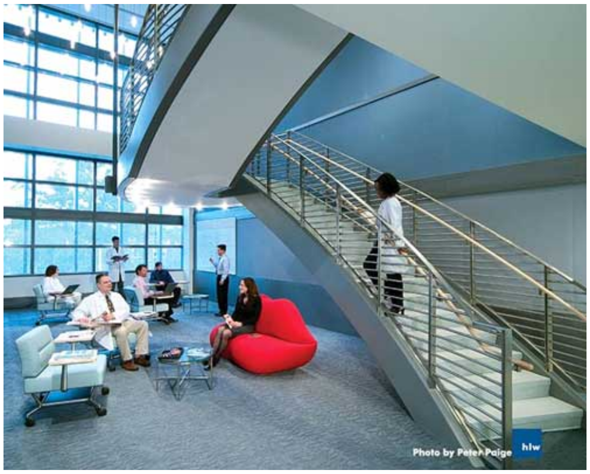
Instead of standard equipment, Arizona State University's Biodesign Institute uses cart laboratories throughout the facility. This progressive set-up is one reason the institute holds *R&D Magazine*'s "Lab of the Year" title for 2006. (*Photo courtesy of Lord, Aeck & Sargent, Photographer Mark Boisclair*.)



The social area at Avon's Global Research and Development Center encourages employees to relax between meetings or discuss the latest research findings somewhere other than the lab itself. (*Photo courtesy of HLW, Photographer Peter Paige*.)

Vision glass creates a safe and secure environment for students working in this lab at North Carolina State University. (*Photo courtesy of Perkins+Will, Photographer Michelle Litvin*.)