# Better Labs for Breakthrough Science

PHOTOGRAPH: OLSON PHOTOGRAPHIC

**Daylight and outdoor views are believed to correlate directly to improved lab productivity and elevated scientist satisfaction. At Yale's Sterling Hall of Medicine in New Haven, Conn., a recently added wing was designed specifically to allow ample sunlight and scenery.**

## Learning Objectives

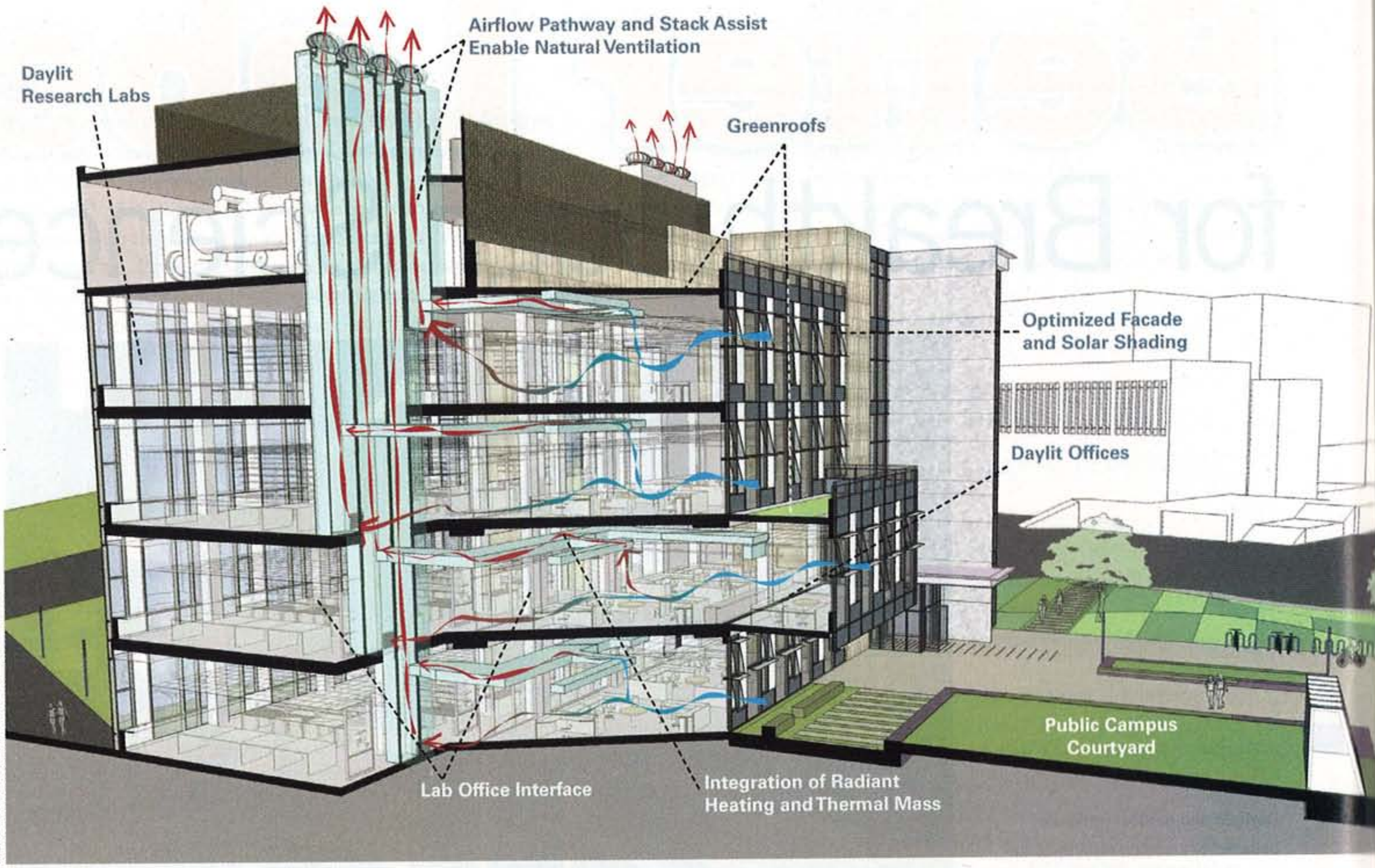
After reading this article, you should be able to:

- ✔ Describe how laboratory and research trends affect building design, especially with regard to energy and environmental conditions
- ✔ Explain how HVAC systems affect lab planning, air quality, and energy use
- ✔ List safety and security considerations for lab facilities
- ✔ Discuss techniques for reducing energy use or increasing work efficiency within laboratory buildings

By C.C. Sullivan and Barbara Horwitz-Bennett

As scientific breakthroughs, technology, and new research models continue to surge forward, today's laboratory Building Teams are scampering to keep up. From new layouts to accommodate translational health science and the stringent environmental requirements of nanoscience, to the increasing support space demands for instrumentation and robotics, lab design is rapidly progressing. Most critical is the effective design of laboratory building infrastructure, which supports the lab bench as well as the talents of today's scientific researchers.

Driving these changes is an evolution in research mindset. One notable and recent change is the overall shift from studying individual molecular structures to researching complex systems as a whole. Consequently, traditional silo-based lab spaces are phasing out, with much greater emphasis on interdisciplinary




RENDERING: COURTESY ZGF ARCHITECTS

**The University of Washington's Molecular Engineering Building, currently under construction, is modeled to reduce the energy required for cooling of the office portion of the building by 98%, or 70,000 kWh annually. Programs like the EPA's Labs21 are addressing the energy concerns of research facilities.**

collaborative spaces.

"More often now, the disciplines are being brought together to form thematic groupings that allow people with different areas of expertise—in other words, wet lab researchers and computational scientists—to collaborate on a common project," states Arlen Li, AIA, LEED AP, associate principal with Boston design firm Payette (www.payette.com). "This has led to laboratory designs that try to foster interaction wherever possible by providing flexible work space that can be changed out for different uses and multiple areas for casual meetings and conversations."

Similarly, traditional uses for lab bench and support area uses have become blurred. "Researchers used to spend most of their time at the bench and would go to the support rooms every now and then to access equipment or process samples. However, that model is increasingly being flipped, where people tend to work more in the support areas than at their benches," adds Li.

Also following this team-based model is *translational research*—new methods of conducting scientific research to make results applicable to a population under study—which is being spearheaded by such influential agencies as the National Institutes of Health (NIH), essentially initiating a whole new approach to disease-based research.

"This bench-to-bedside approach has created opportunities for basic scientists and clinical researchers to collaborate in integrated teams, with both working at the bench and seeing patients," explains Victor Cardona, AIA, vice president and director of lab planning, SmithGroup (www.smithgroup.com), Detroit. "This has created a co-location of thematically organized research-patient care centers, with the co-location of patient clinics in research buildings."

For instance, SmithGroup's design of the new Cardiovascular Research Center at the University of California's Mission Bay campus will provide space for both research laboratories and patient clinics, enabling researchers to better follow clinical applications.

In addition to integrating the labs and clinics, says June Hanley, LEED AP, principal laboratory planner with HDR CUH2A (www.hdrarchitecture.com), Princeton, N.J., one of the keys to translational health science is getting the right people to speak to one another. "Facilities need to be carefully designed to connect these groups, or members of these groups, through well-equipped and well-located office, lab, team, and amenity space," she says.

These factors are changing the look and feel of laboratory and support spaces, says Robert B. Skolozdra, AIA, LEED AP, partner and sustainable design specialist with Svigals + Partners, New Haven, Conn. (www.svigals.com). "Some strict rules of lab design from a few years back are changing swiftly to accommodate new, collaborative work approaches," he says. "The interior environment has more daylight, more informal meeting areas, and more flexible building systems to allow reconfiguration."

Skolozdra describes the use of these novel lab concepts at Yale University's Department of Genetics, where Svigals & Partners co-located a large break room, a conference room, and several offices on the courtyard side of the facility with direct connections to the court through glass doors.

## WILD CARDS OF EMERGING SCIENCE

Another trend necessitating an entirely different set of facility requirements is the world of emerging science, such as nanotechnology and other wild cards in the future of lab design and construction.

"The stringent requirements of nanoscience call for facilities to be designed with much greater stability in terms of vibration, temperature, humidity, electromagnetics, and acoustics," explains Mark Reed, AIA, LEED AP, principal and vice president with Tsoi/Kobus & Associates (www.tka-architects.com), Cambridge, Mass. Consequently, these labs must be designed and built with a high level of precision, not to mention cost.

Driven by cutting-edge science in this and other fields, another significant trend influencing lab design is the continued integration of the latest in robotics and instrumentation technology into the research process. As a result, equipment footprints are taking a higher share of real estate, as compared to square footage for human workspaces.

"With increased automation, there is a shift toward dedicated, 'process-repetitive' instrument labs that are often less demanding on infrastructure," says Deepa Dhar, AIA, LEED AP, a principal with Santa Clara, Calif.-based Folio Architects (www.folioarchitects.com). He offers the example of high-performance liquid chromatography machines. "These less infrastructure-intensive spaces can accommodate larger research areas, and the specialized equipment that requires a special environment and infrastructure is often shared by a variety of groups," she explains.

The infrastructure in question is dominated in operating cost and energy draw by heating, ventilation and air-conditioning (HVAC) systems, which account for a whopping 50% of a typical lab's power use, says Skolozdra. With that in mind, a number of strategies—in particular, chilled beams, high-performance fume hoods, right-sizing equipment, and reducing air changes per hour—can help slim down the energy profile.

## CHILLED AND EXHAUSTED

Although *chilled beams* have been traditionally viewed as a relatively expensive, bleeding-edge technology, they are a tried-and-true application in European building interiors. This is quickly boosting

PHOTOS: COURTESY HDR CUH2A

**Providing affordable modern laboratory space and production facilities to both young, growing firms and larger established companies, the New Jersey Economic Development Authority Technology Center, New Brunswick, is a science park offering full utilities and amenities. Designed by HDR CUH2A, the lab follows LEED Commercial Interior standards and includes energy-efficient systems such as chilled beams and dual energy ventilation.**

PHOTO: OLSON PHOTOGRAPHIC, COURTESY SVIGALS + PARTNERS

**Along with lab zones, common areas such as cafés, lobbies, and corridors should also encourage interaction. A bright, open lounge attracts groups for discussion and informal meetings at the Center for Science, Art and Technology on the campus of Albertus Magnus College, New Haven, Conn.**

their acceptance in U.S. research institutions.

"Chilled beams have passed from being an 'exotic' cooling solution to a technology that we employ on many of our laboratory and office projects," says Joseph Collins, AIA, NCARB, LEED AP, a partner with ZGF Architects, Portland, Ore. (www.zgf.com). "Like any technology, it was initially projected to be more expensive due to lack of market share, but even with those original premiums, chilled beams have proven to deliver a quick payback on initial capital investments."

SmithGroup's Cardona, an author who specializes in bioscience research, teaching laboratories, engineering and material sciences labs, and translational research design, says, "Chilled beams are becoming very popular, with both passive and active systems that use chilled or process water, rather than relying on the ventilation air to cool laboratory spaces. Now we are applying them to labs, but given the space composition of today's lab—including multiple sciences and both wet and dry lab environments—we find that we are combining multiple systems under one building."

Another important technical advance is the *high-performance fume hood*. These also cost more, says Cardona, but the efficient systems also claim potential energy savings of as much as 50% while maintaining or improving containment over standard models.

Another advance stemming from Europe—mainly for instructional labs where all chemicals in use are known entities—are the highly promising *ductless fume hoods*.

"Ductless hoods recirculate exhaust air back into the room through a carbon filter package," explains Cardona, adding that these fume hoods have been "difficult to apply" to research labs where there are many unknowns. "But the technology is changing, with new products that potentially can accommodate a greater number of chemicals. It is not the answer to all applications, but as more filed data becomes available we are starting to consider it in more projects."

Another noted fume hood innovation is the *zone presence sensor*, a detection device installed directly on the hoods. According to George L. Kemper, a laboratory and vivarium planner with BHDP Architecture, Cincinnati (www.bhdp.com), the sensors trigger the hood to drop down to a minimal air flow to maintain containment when there is no one in the occupancy zone, while shifting to a higher volume of air flow (measured in cubic feet per minute) when an operator is present.

Beyond these new technologies, simply rightsizing the HVAC equipment can go a long way toward increasing efficiency. As promoted by the U.S. Environmental Protection Agency's Laboratories for the 21st Century initiative, better known as Labs21 (www.labs21century.gov), significant energy savings are possible in any lab. The voluntary program compares power usage of actual connected loads to labs with similar science programs to establish more efficient yet realistic targets.

By applying this methodology while designing Lawrence Berkeley National Laboratory's new Molecular Foundry building, SmithGroup discovered many over-designed labs with excessive watts-per-square-foot allocations. By rightsizing HVAC and lab equipment loads for this project, taking into account both connected loads and future flexibility, SmithGroup capitalized on a 35% reduction in the air handing load, a 30% reduction in the boiler capacity, and a 35% reduction in the chiller load, ultimately slicing $2 million off the project budget.

Lab facility engineers and sustainability advocates emphasize the importance of scrutinizing air-changes-per-hour (ACH) turnover for ventilation. While traditionally operating under a "more-is-better" philosophy, labs have been fully outside-air ventilated at 10 to 12 ACH, thus requiring very high energy levels to move and temper the air, according to Cardona. On the contrary, he says, "Our more recent projects have been designed at six air changes per hour for lab spaces, which has been shown in newer facilities to be adequate for providing a safe lab environment in typical operating conditions. Reducing the air change rate to half the previous standard naturally results in significant energy savings."

## LABS AND THE INDOOR ENVIRONMENT

Even though such significant reductions in ventilation rates are raising concerns about maintaining high indoor air quality (IAQ), new technologies such as *air-sampling systems* are helping to allay these anxieties among researchers. "These devices, much like a smoke detector, can monitor the cleanliness of lab air and filter for certain chemical concentrations. When a given concentration is exceeded, it triggers an increase in supply and exhaust air change rates," says Tsoi/Kobus principal Reed.

Embracing this new advance, research institutions have employed air-sampling technology with great success. The University of Louisville, for example, recently installed air sampling in its Clinical and Translational Research Building, with a calculated annual savings of $84,564 and a 3.2-year payback.

Not quite as innovative but also effective is applying *demand-controlled air quality* to IAQ. "By measuring CO2 levels, volatile organic compounds, and the like to determine the correct amount of supply air, labs can make people more comfortable. It's better for the science, and it's more energy efficient," says Jonathan Barnett, PhD, PE, technical director of fire/life safety with AECOM.

Barnett is also seeing a push to test the value of operable windows in the office areas of U.S. lab facilities. This is a design requirement in other countries, notably in Europe.

**Editor's Note**

**Additional required reading online! To earn 1.0 AIA/CES learning units, complete the required reading and take the CEU test posted at www.BDCnetwork.com/BetterLabs.**

## LABS MODULE

**Pass this exam and earn 1.0 AIA/CES learning units. You must go to www.BDCnetwork.com/BetterLabs to take this exam!**

1. An evolution in research methods is behind the ongoing phase-out of traditional, silo-based lab spaces, to more interdisciplinary collaborative spaces coming online. The reason is an overall shift:
   A. From using teams of scientist to using robotics.
   B. From studying complex systems as a whole to researching individual molecular structures.
   C. From studying individual molecular structures to researching complex systems as a whole.
   D. None of the above.

2. Advances in lab worker protection and the improved efficiency of HVAC systems include:
   A. High-performance fume hoods
   B. Ductless fume hoods
   C. Zone presence sensors
   D. All of the above

3. True or false: In a change from the typical use patterns, lab researchers today are increasingly spending more time at the lab bench and less time in support areas.
   A. True.
   B. False.

4. Heating, ventilation, and air-conditioning (HVAC) systems typically account for about how much of a typical lab's energy use?
   A. About 50%
   B. About 10%
   C. About 75%
   D. About 90%

5. Chilled beams include both passive and active systems. Rather than relying on the ventilation air to cool laboratory spaces, chilled beam systems use:
   A. Chilled or process water.
   B. Reclaimed grey water.
   C. Backup power systems.
   D. District cooling plants.

6. True or false: The use of low-VOC building materials in laboratories for lab projects that are tracking LEED certification does not affect regulatory assessments of indoor air quality.
   A. True.
   B. False.

7. In recent years, laboratories have typically been ventilated at 10 to 12 air changes per hour (ACH). Reducing the energy requirements to move and temper the air, new lab spaces are being designed at what level of air changes per hour?
   A. 2 air changes per hour.
   B. 4 air changes per hour.
   C. 6 air changes per hour.
   D. None of the above.

8. To regulate chemical quantities used in laboratories, Building Teams are required to follow the IBC (International Building Code) for permits, construction, and occupancy. On the other hand, lab operators and users, health and safety staff, and insurance companies typically are guided by:
   A. NFPA 45.
   B. ASTM D737.
   C. MSDS databases.
   D. FTC Consumer Protection standards.

9. For lab areas with highly hazardous materials, Building Teams can use a leak-tight, pressurized barrier system designed for hazardous pharmaceutical compound handling. These systems, which prevent migration of hazardous contaminants to the outside and minimize cross contamination, are known as:
   A. Positive pressure chambers.
   B. HEPA.
   C. Isolator technology.
   D. None of the above.

10. What kinds of life-safety systems are designed to automatically alert laboratory safety personnel of a developing fire emergency in its earliest stages, before it activates standard automatic fire-suppression systems?
   A. Automatic gas-detection systems.
   B. Fire separation assemblies.
   C. Access control systems.
   D. Spot-type or zoned air-sampling smoke detection.