

LABORATORY Design

From the Editors of R&D Magazine
August 2003 Vol. 8, No. 8

PROJECT SPOTLIGHT

Renovation/construction project rejuvenates chemistry facility

The Project: Univ. of Wisconsin-Madison, Department of Chemistry construction/renovation initiative. Multi-phased 414,000-ft² (gross) project included construction of a new 91,000 ft² (gross) research tower; new 6,065 ft² (gross) seminar/lecture hall; and renovation of two 1960s-era facilities: the Mathews Building (87,143 ft² renovated) and the Daniels Building (229,493 ft² renovated). \$41.8 million (research tower \$222/ft²; seminar hall \$445/ft²; renovation averaging \$54/ft²).

The Team: Flad & Associates, Madison, Wis. (architecture); Flad Structural Engineers, Madison (structural engineering); Affiliated Engineers, Madison (MEP engineering); Kapur & Associates, Madison (piping engineering); Barrientos & Associates Inc., Madison (civil engineering); Soils & Engineering Services Inc., Madison (soils engineering); Earl Walls Associates Inc., San Diego

New and renovated UW-Madison chemistry facilities include (left to right) the research tower, Mathews Chemistry Laboratories, Daniels Chemistry Building, and lecture/seminar hall (right foreground). Photo: Steve Hall/Hedrich Blessing.

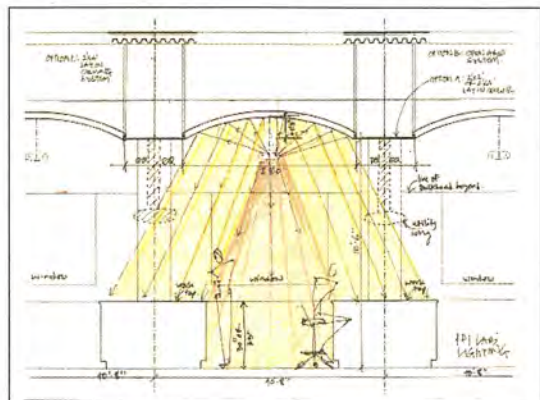


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Modular design maximizes laboratory flexibility

By Jayesh Hariyani

Reconfiguring laboratories to handle new research projects is a major drain on laboratory resources. Not



only does it cost money to tear out old fixtures and install new ones, but every day that the lab is under construction is a day that it is not generating revenue. A relatively new concept in laboratory design, the modular laboratory, offers the flexibility needed to reconfigure labs with minimum cost and downtime without sacrificing efficiency, safety, and user satisfaction.

A module has two important characteristics that make it appropriate for laboratory layouts: it is a standardized unit that can be organized in a variety of ways, and it can be a self-contained unit with a specific purpose. Modules are essentially architectural building blocks, featuring standardized spacing of various key infrastructure elements. Because modules are standardized, reconfiguration is more simple, predictable, and economical than with lab buildings where each space is

Fig. 1. Typical laboratory module width (10-ft-8-in. module)

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NEWS NOTES

• **Feds map IAQ research agenda** With limited research dollars available, and a seemingly unlimited number of indoor air quality issues to study, the U.S. Dept. of Energy recently developed a prioritization of IAQ research topics. Developed in concert with the Association of State Energy Research and Technology Transfer Institutions, the 93-page agenda describes how building energy use and IAQ are linked; summarizes ongoing research; and identifies 35 top-priority research areas. Not surprisingly, HVAC systems and moisture control are prominent topics. For more: <http://eetd.lbl.gov/ied>.

• **All shook up** Think seismic issues are a pretty minor aspect of building design if your lab isn't in a traditionally earthquake-prone zone? Your local code officials might disagree. Both the new "consensus" codes vying for

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NEWS NOTES

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nationwide adoption—the International Building Codes and the NFPA 500 code—take a hard look at seismic design, referencing recent recommendations by the American Society of Civil Engineers. The codes consider not only traditional geographic measures of seismic risk but also building occupancy type and the soil conditions at the individual site. If the soil is poor and the occupancy (or building hazard type) is high, the building may fall into a higher seismic design category even if the area's perceived seismic risk is relatively low. For an overview of the key issues: www.bdcmag.com/magazine/articles/b03f052.asp.

● **Hoosiers give tech parks seal of approval** Indiana has inaugurated a new Certified Tech
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Renovation/construction project

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(programming); Kirkegaard & Associates, Chicago (acoustical and audiovisual consult-

ants, seminar hall); J.P. Cullen & Sons, Janesville, Wis. (general contractor).

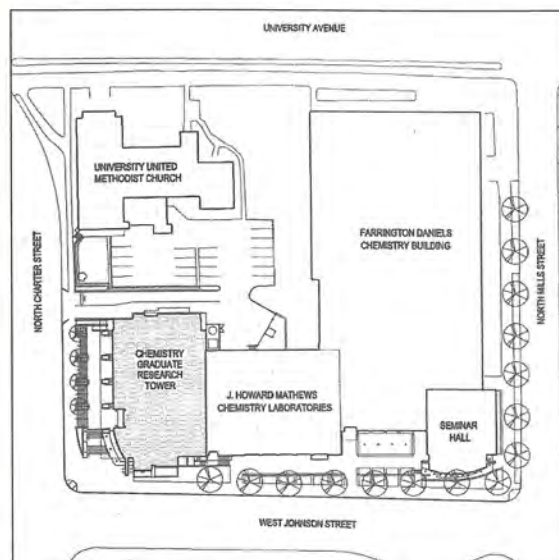
The Users: Undergraduate/graduate students and research/teaching faculty of the Univ. of Wisconsin-Madison chemistry department.

Occupancy: Combined facilities accommodate ~425 faculty/graduate researchers; some 4,000 students use the complex's classrooms daily each semester.

The Schedule: Conventional design/bid/build, with several hiatuses during the process. Planning/programming commenced May 1992; research tower completed fall 2000; seminar hall and renovations completed fall 2002.

The Goals: The Univ. of Wisconsin-Madison chemistry department is a highly respected academic organization that has nurtured top-notch research by both faculty and graduate students. But until a few years ago, they were working in a pair of 1960s facilities, including labs with outmoded safety provisions.

In addition to overall lab and safety improvements, the client's concerns



The research tower has a prominent entrance that created a new "front door" for the entire chemistry facility. Plan: Flad & Associates.

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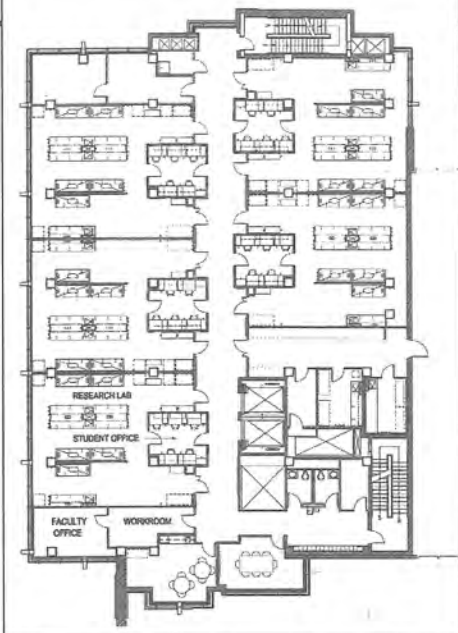


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Research floors of the new tower building consist primarily of graduate labs and office space, with a few faculty offices on each floor. (Other faculty have offices elsewhere in the chemistry complex.) Plan: Flad & Associates.

included:

- A need to recruit top faculty and students (dif-

ficult with substandard facilities).

- A need for more up-to-date infrastructure supporting modern instrumentation and HVAC requirements.

- An inadequate quantity of space to serve the department's enrollment and mission.

- A lack of consolidation (for instance, administration, business services, admissions, records, and the mail room were inconveniently scattered).

- A demand for better library resources, with greater access to electronic information.

- The lack of a quality lecture/seminar hall with modern AV and communications infrastructure.

Though these issues were important to university and departmental officials, some faculty members were concerned that addressing them would take important money away from research. "Many faculty were skeptical of the need to expend precious resources for what was initially perceived as a 'cosmetic' renovation," says chemistry professor Robert J. McMahon—who adds that the improved attractiveness and functionality, along with a reconfigured corridor scheme that brings all four building elements together, was well worth the investment.

"Our new primary thoroughfare, which we have affectionately dubbed the 'Main Street Corridor,' unifies our department, projects a

welcoming environment to students and visitors, and provides a wonderful vehicle for public outreach," he says.

The Solutions: Because the university's existing Daniels and Mathews chemistry buildings were well worth saving—but not adequate to meet current departmental goals, even with renovation—the design team's scheme for the project evolved to encompass three main phases:

- A new research tower providing state-of-the-art lab space.

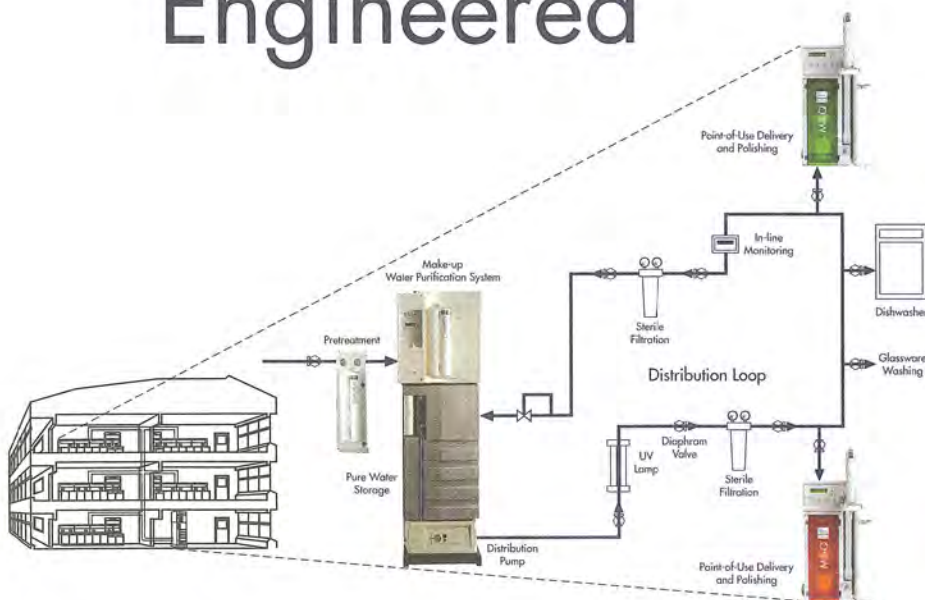
- A new seminar/lecture hall, usable by all members of the department.

- An upgrade of labs in the Daniels and Mathews buildings.

As with many academic renovation/construction projects, the first priority was creation of the new research tower, so operations could proceed there during renovation of the older facilities. Dedicated in fall 2000, the eight-story tower (plus a rooftop mechanical zone and basement mechanical space) anchors the site's southwest corner, which was previously occupied by a small parking lot and a couple of nondescript houses. The tower now provides graduate-level labs and support space, an instrument center, and imaging facilities. Synthetic chemistry, which demands labs capa-

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Renovation/construction project

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ble of hazardous operations, is a strong focus.

A two-story atrium grounds the building, providing a new front door for the entire chemistry complex. Key administrative and instrument support rooms are also housed on the first and second floors, and are separated from the upper group of lab floors by a full-height mechanical floor that holds the air handlers for the entire facility. The high placement pulls cleaner air into the building than would be available from street-level air intakes, since the parcel is bounded by thoroughfares that see heavy vehicular traffic.

Labs are situated at the east and west building perimeters, double-loaded along a central corridor. Small group offices seating 5 students each jut into the lab environment and can be entered from both the corridor and the lab. The office modules are separated from the corridor as well as the associated labs by walls, but the walls are amply glazed to allow views to the lab, corridor, and building exterior from within the offices. A handful of faculty offices are placed at building corners; only faculty who are directly supervising student researchers in the tower have offices there. (Others have offices in other chemistry buildings.)

The Mathews and Daniels buildings both received lab space renovations, including increased fume hood access for students at workstations and the installation of point-exhaust systems to improve bench-level ventilation. Upgraded equipment was installed in some labs. In the Mathews building, which consists primarily of research labs, student desks were taken out of the lab space and relocated to a new office/support zone adjacent to the labs. Renovations were less extreme in the Daniels building. Due to the renovations and construction, the students-per-hood and students-per-bench ratios in both existing research buildings were reduced to a safer and more efficient level.

Like the existing facilities, the research tower is composed of rectilinear forms, but its strongly vertical lines give the complex a new sense of importance and strength. Photo: Steve Hall/Hedrich Blessing.

Finally, the new seminar hall was added to anchor the southeast corner of the site, butting the corner of the Daniels building. The seminar hall "bookends" the southern edge of the complex, complementing the exterior design of the research tower at the southwest. The placement of the new facilities allowed creation of the L-shaped 'Main Street' corridor that traverses the south side of the parcel (through the research tower, Mathews building, and south side of the Daniels building), then turns northward to proceed along the east side of the parcel (through the remainder of the Daniels building).

The Highlights: Lab floors in the tower are 16 ft floor-to-floor, compared with 12 ft in the existing buildings, providing room for more intensive infrastructure. Each student now has a fume hood to work in, rather than having to share—setting a new campuswide standard for departmental facilities and any future renovation phases. The decision to separate student desks from the lab is also a new departmental initiative.

"The student office provides excellent visibility of the wet lab, while at the same time providing an extra margin of safety for our students," says McMahon. "Our students appreciate having computers and shared peripherals right in their office, and they appreciate a quiet place to read, write, and talk about science. And everyone loves the bright, cheery environment afforded by the large windows."

The soaring verticality of the new research tower—emphasized with



Graduate students now have well-equipped labs that enjoy considerable daylight. Synthetic chemistry is a primary focus of the tower building. Photo: Steve Hall/Hedrich Blessing.

metal fins—makes a strong statement for the department, without clashing with the horizontal rectilinear forms of the existing buildings (which had no exterior renovations).

The lecture hall combines rounded and rectilinear forms, creating an exterior expression of the “amphitheatre” but still harmonizing with its neighbors. An unusual feature of the lecture hall is a combination of pear-stained maple paneling on the lower part of the interior walls and “sintered” aluminum panels above. This construction material consists of ground alu-

minum that has been pressed into a thin, brittle, porous panel, whose irregular surface geometry allows sound to pass through, but not reverberate. The material is widely used in Japan but is rare thus far in the U.S. The design team liked the combination of wood (with its traditional academic feel) and metal (with its high-tech connotations) for this heavily used hub. Wood is also a primary material in the research tower atrium and in the lab and office casework.

The Results: During tower construction, five top faculty members resisted outside offers for other jobs, and five new faculty members were recruited. Departmental officials give the new facilities at least partial credit for these successes. “Competition for the very best students and faculty is fierce,” says McMahon. “Our new building gives us an advantage.”

McMahon says the consolidation of previously discrete operations—including a study room, computer lab, computer classroom, teaching assistants’ office, and renovated library—has also been a big boost to promoting a more cohesive feeling among faculty and students.

He concludes: “The addition/renovation project created a substantial impact on the entire spectrum of activities within our department. The design concepts for each element of



Office modules are easily visible from both the central corridor and the lab area, and offer writeup and research space for five students each. Photo: Steve Hall/Hedrich Blessing.

the facility work extremely well, and the aesthetic qualities of the facility appeal to both the occupants and the entire community. We are proud of our building because it is both functional and beautiful.”

The Contact: David W. Black, AIA, design principal, Flad & Associates. 608-238-2661; david_black@flad.com; www.flad.com.

—Julie S. Higginbotham, editor

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Modular design

continued from page 1

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The main considerations in modular laboratory design are:

- Functional requirements of the lab.
- Module geometry (width and length).
- The building floor plate.
- Engineering and distribution systems.
- Casework.
- Lighting.

Functional lab requirements

To lay the foundation for a successful laboratory design, the design team must understand the requirements: the types of laboratories, containment levels, and shared functions that will be required for the facility, whether new or renovated. Most contemporary laboratories contain three kinds of labs, each with distinct design requirements. In order of importance they are:

■ **The general research lab.** Intended to be flexible, open, and adaptable to layout variations as programs, funding, or research

interests change. Ease of reconfiguration should be an essential goal for this type of

research lab. Researchers and staff must be able to change bench arrangements without help from the facilities department or outside contractors. Modular furniture, utilities, distribution systems, and equipment are ideal for achieving these goals.

■ **The support lab.** Houses equipment for procedures needed to operate a general research lab, but whose presence in the general research lab would limit its flexibility. In a modular design, fume hoods, sinks, and other fixed items are located in these spaces, which are typically adjacent to the general lab. Depending upon the level of containment and accessibility required, a support lab can adjoin the general lab space (often across a ghost corridor) or be in a nearby room. Examples of support labs are tissue culture labs, equipment rooms, darkrooms, environmental chambers, microscopy suites, and DNA and protein sequencing labs.

■ **The core lab.** Typically houses single pieces of equipment used occasionally by all general research labs. There is usually only one core lab in a lab building. Core labs

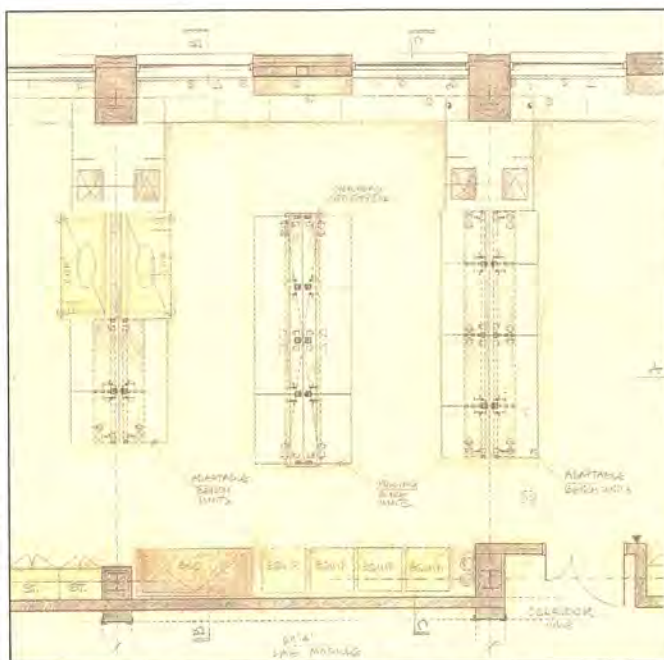


Fig. 2. Laboratory module: two 10 ft 8 in. modules combined, including an island bench and peninsula benches, with an equipment zone across a ghost corridor.

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tend to be the least flexible labs and are expensive to build and change. Examples of core labs would be labs for scanning electron microscopy, transmission electron microscopy, nuclear magnetic resonance spectroscopy, fluorescence-activated cell sorting, confocal microscopy, atomic force microscopy, high-pressure liquid chromatography, and gas chromatography-mass spectrometry.

Labs may also require environmental rooms, equipment rooms, glassware preparation rooms, chemical storage and handling areas, physical plant facilities, staff offices, and break and conference areas. Spaces and HVAC systems for individual functional areas may have to be separated to prevent cross-contamination, as well as for operational efficiency.

Module geometry (width) Understanding the requirements, the design team will be ready to begin analyzing the modular geometry that best organizes functional spaces. The team must first determine the mathematical overlapping of the dimensions of various building systems, such as structural, HVAC, plumbing, and electrical and telecommunications distribution, to ensure maximum efficiency in delivering these services to the labs.

A basic module in the form of a rectangle from 10 to 12 ft wide and from 25 to 35 ft long

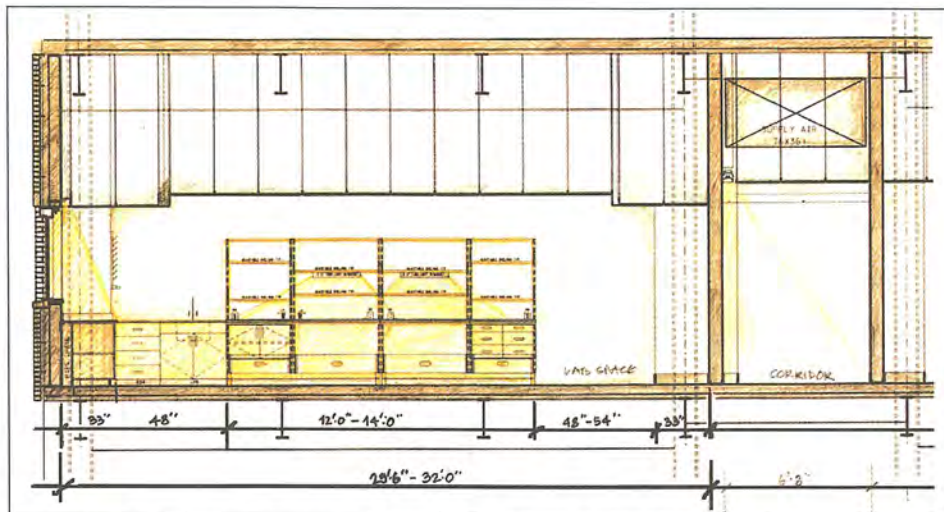


Fig. 3. Typical laboratory module length (29 ft to 32 ft module), configured with a tech writeup space at the outside wall.

usually accommodates most functional systems in a lab.

Module width is directly correlated to user circulation. It determines comfort, function and safety, especially when a large number of researchers and technicians are to share a space. Figs. 1 and 2 (page 1 and page 6) show an optimum module width, between 10 ft and 11 ft 4

in., for typical laboratory bench and equipment arrangements. A module wider than 12 ft should be used only for specific needs, such as for mass spec or in a split-bench laboratory or human testing lab.

Using a 4- or 6-in. increment for the module width reduces design and construction costs.

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Modular design maximizes lab flexibility

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For example, most laboratory ceilings are lay-ins with components available in 2-ft increments. When this ceiling system is overlaid onto a lab bench module planned in increments of 4 to 6 in., overhead fixtures easily align with lab benches, fewer ceiling tiles have to be cut, and the lab has a more finished look. Good examples are module widths of 10 ft, 10 ft 4 in., 11 ft, or 11 ft 4 in.

Aisle width within a module is also a key to ensuring safe movement of personnel and equipment. People who handle and transport large quantities of biological material need room to work and move safely. All personnel need unobstructed access to emergency exits. A laboratory containing specially sized equipment or one with heavy laboratory cart traffic may require wider aisles. When aisle width exceeds 4 ft

6 in., however, users have a tendency to clutter up the open space with equipment, containers, or furniture, which compromises function, safety, and ease of movement.

Module geometry (length) Module length is subject to fewer constraints than module width. Fig. 3 (page 7) illustrates a variety of linear dimensions. Casework typically runs parallel to the length of the module. The use of multiple-module laboratories, the most typical being the double-wide or two-module

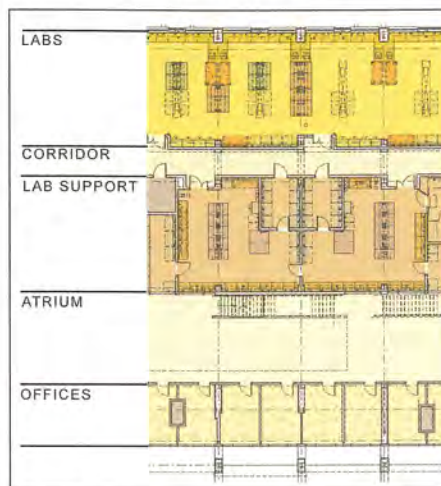


Fig. 4. A lab, lab support, and office arrangement that removes primary administrative spaces from lab spaces.

laboratory layout (Fig. 2), may reduce module length. In the multiple-module laboratory, the bench on the shared module line will be an island. The length of the island bench determines module length.

Other factors that can influence module length include the location of technical workstations, the divisibility of the module into smaller units for functional needs, and the ceiling system used.

Typical laboratory design criteria dictate that there be 10 to 14 ft of uninterrupted, usable worktop for each investigator. This translates to an optimum bench length of 12 ft. to 14 ft. to allow for the sink that will most likely be needed at one end of the bench. Combining the work surface, sink, the aisle at sink end, and a traffic path at the opposite end brings the typical module length to 22 ft 9 in. to 26 ft 3 in. Depending on the lab's functions, an equipment space opposite the sink at the end of the island (3 ft) and a work area opposite the non-sink end of the island (4 ft) could be added. The total required length of the module would then be 27 ft to 32 ft.

In today's laboratory, almost everyone does routine paperwork on a computer. For this purpose a laboratory frequently contains a number of technical workstations as a series of 4- to 5-ft desks. These desks are typically located on an exterior or window wall because of concerns for safety and glare reduction. All desk work should be performed a safe distance from potential hazards at the laboratory bench. Technical workstations can create a buffer zone between a corridor and the laboratory and reduce traffic. Other solutions include locating the workstations in a pod to one side of, or across the corridor from, the laboratory or creating shared work space somewhere nearby (Fig. 4, above).

The laboratory module is usually divisible lengthwise into smaller rooms. Keeping the division factor the same for all modules in a building is a good organizational strategy: it helps reduce costs, makes it

easy to design engineering services, and facilitates standardization of architectural features as doors, casework lengths, and ceiling systems.

Building floor plate Once the designer has established the module size required to perform lab functions, the next step is to analyze how well its dimensions fit the building floor plate and to make adjustments.

Building structural features that can affect module width include the building grid and bay size, exterior window placement, corridor width, the relationship of the door and corridor to the laboratory entry, and the type of ceiling systems. The designer must give serious consideration to the total building width in deter-

mining the corridor width for both staff and service access to the laboratories.

Older facilities tend to have oversized corridors that frequently become repositories for freezers and other lab equipment, in violation of building code requirements to keep exit routes clear. It is best to size corridors so the equipment will not fit anywhere except in the places that are designed to accommodate it. A corridor width of 5 to 6 ft is satisfactory for the circulation of people, materials, and equipment in most laboratories. Corridors that end in tight

corners should be avoided: it is not easy to maneuver carts and equipment around a 90° turn unless there is swing room.

Engineering and distribution systems

The modular concept provides a regular, organized approach for engineering systems: supply and exhaust air; piping for water, gases, and wastes; electrical power distribution; communications cabling; and safety systems. Modular engineering systems can reduce construction cost and time through standardization and

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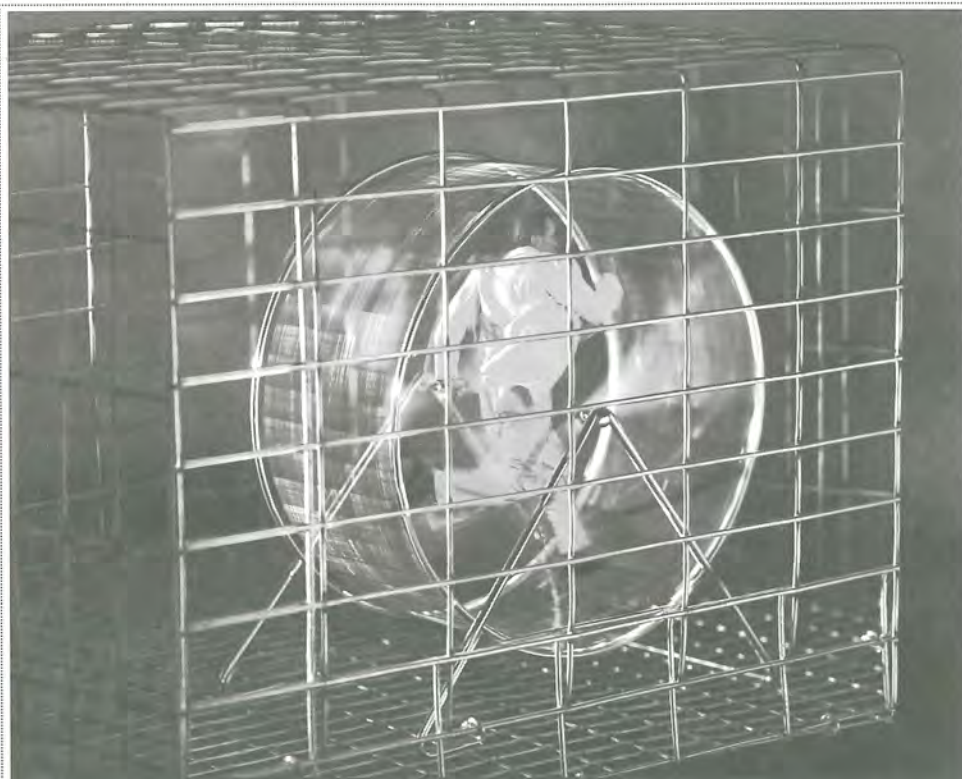


Fig 5. Modular lab and casework design maximizes flexibility to meet project requirements. In these designs, an overhead service carrier and movable casework units enhance the owner's ability to reconfigure lab spaces.

Laboratory Design (ISSN 1089-1331) is published monthly by Reed Business Information, a division of Reed Elsevier Inc., 350 Hudson St., New York, NY 10014-4504.

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Modular design maxes flexibility

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economies of scale. Typically, the main components of these systems can be located at regular intervals in the building.

To ensure adequate plenum (above-ceiling) space for these systems, the design should allow at least 4 ft between the ceiling plane and the underside of structure. The optimum ceiling height in a laboratory is 9 ft, and the structural systems generally require 2 ft. Additional plenum space will make future modifications easier. The potential savings in accessibility and maintenance time should be weighed against the initial cost of the added height.

The need to keep maintenance personnel out of particularly sensitive lab areas may drive a decision to increase plenum space to a fully or partially walkable interstitial space. It is not unusual for a single building to combine a vivarium (with partially or fully walkable interstitial space) and research labs (without interstitial space).

Casework The modular concept can readily be applied to laboratory casework (Fig. 5, page 9). Designers need to work with manufacturers of laboratory casework systems to develop products that allow for storage cabinet flex-

ibility, service outlets that do not require a plumbing contractor, and adjustable bench heights, locations, and sizes. In an analytical laboratory, the bench-top working height, task light, and associated shelves should be adjustable for maximum flexibility. More and more laboratory processing work is mechanized and computerized. This requires space and connections for computers and peripherals and sometimes a temperature—or humidity—controlled environment.

A traditional 30-in.-deep laboratory bench may not be suitable for modern lab equipment. The standard recommendation today is a 33-in.-deep lab bench. One way to increase work space is to provide pull-out shelves directly under the counter for use as a writing surface. Service outlets should be located at the ends of benches to provide maximum flexibility for equipment placement.

Lighting Equipment use determines lighting requirements for the bench top. A work surface used for manual manipulations requires bright direct light in the range of 75 to 100 foot-candles. A surface where instrumentation or equipment is used usually requires less light, but there must be enough to read gauges.

Modern laboratories have many computer monitors on the benchtop. Windows opposite

the screen cause glare and reflection problems, and bright overhead fluorescent lights can cause discomfort. The use of parabolic light troffers, especially the multiple, deep-cell type, can solve these problems. More cells provide better light distribution. Overhead lights should be parallel to the bench and near the bench edge. If lights are located too far out in the aisle, the person working at the bench will cast shadows on the bench work area.

A combination of overhead parabolic and task lights can achieve the required foot-candle intensity at a workstation. General laboratory lighting should be within the range of 60 to 80 foot-candles in the main laboratory areas. Lighting in intensive work areas should be boosted to 100 foot-candles with task lights. Analytical laboratory areas may require only general lighting at a higher foot-candle range or specific task lighting, depending on the laboratory's function.

Modular laboratory design based on these principles is the best approach to maximizing laboratory flexibility and minimizing costs to build, equip, and reconfigure labs.

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