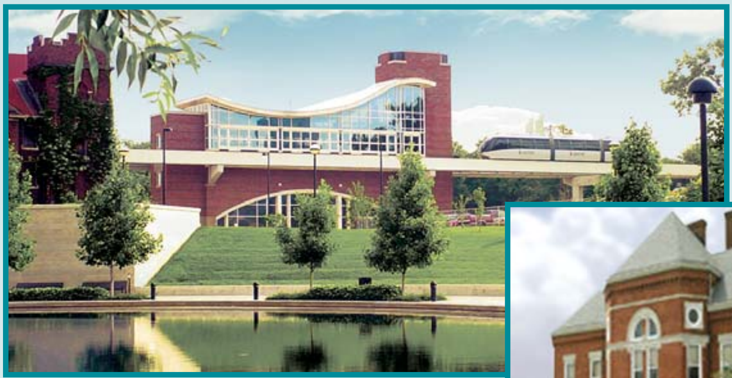
From age to age: the American laboratory



The Old Pathology Lab juxtaposed against the new Clarian Health.

Photos by Norma Erickson

From the 1890s' inception of the medical laboratory in the United States through the advent of futuristic technology in today's lab design, the workplace for medical technicians and technologists has required attention to the smallest detail. Whether the laboratory was a dream in the mind of an early hospital superintendent or the vision of a modern-day, tech-savvy architect, its components range from configuring space and supplying equipment to establishing appropriate workspace for lab techs.

Preservation contrasts with progress

By Norma Erickson

In the late 19th century, U.S. medical schools, universities, and hospitals began to establish laboratories — ranging from a spare room near the morgue to large buildings — to research and diagnose disease.[1] Certain forward-thinking men appealed for laboratory space for scientific pursuits.[2] In 1895, the William Pepper Laboratory at University Hospital at the University of Pennsylvania[3] was recognized as the first clinical laboratory building in the United States by an important early American pathologist, William H. Welch, in his dedication speech.[4]

That same year, construction of the first freestanding U.S. research laboratory began outside Indianapolis at the Central Hospital for the Insane. What is now known as the Old Pathology Building is the last remaining 19th-century pathology lab building in the country and is included on the National Register of Historic Places.[5] The laboratory was in use from its 1896 dedication, when no useful medicinal treatments for psychiatric disorders existed, until the mid-20th century, when the first antidepressants came on the market.[6]

During that era, insane asylums undertook the study of the pathology of the mental diseases when new theories and their application emerged.[7,8] The preserved Old Pathology Building allows present-day scientists to experience a time when the new disciplines of clinical chemistry, bacteriology, histology, and photography were first applied to the effort to solve mental illness.

In the 1870s, pathology essentially meant gross dissection, bacteriology, histology, and some chemical tests on fluids. After Pasteur's and Koch's works were accepted, and because of the almost immediate benefit of better public health, the new science of bacteriology drove the creation of laboratories — with histology its close companion.[9] Ira van Gieson, an outstanding researcher of the time, was considered both a bacteriologist and a histologist.[10] For the physicians caring for the mentally ill (known as alienists), ultimately the question was: Would public and private benefactors financially support the area of experimental pathology applied to psychiatric research?

Although we have moved beyond the notion that demonic possession causes insanity, doctors of that era could only scratch their beards and dispense "homegrown" remedies for the mentally ill. When Dr. George Edenharter became superintendent of Central Hospital for the Insane in 1893, his dream was to put the state's resources behind the quest to cure mental illness. While not a pathologist, Edenharter already had established a lab at City Hospital of Indianapolis (now Wishard Memorial Hospital) while he was its superintendent. In designing the new lab, he turned for assistance to van Gieson.[11] Edenharter envisioned four rooms on one floor; he ended up with two stories, 19 rooms, telephone service, and steam heat. The original floor plan shows the emphasis on bacteriology and histology in rooms near the pathologist's private research lab and office. These two elaborate work areas, with north-facing windows for indirect sunlight, featured round island benches, useful for demonstrating experiments to small groups of students.

Education was highly important to the pathological department's success. Most hospitals of the day were not associated with a university. Medical colleges were proprietary ventures, usually equipped only with lecture space. Edenharter developed a curriculum that invited students from local schools to take advantage of the new research building, and he filled the comfortable library with 500 of the most recent medical books. (Autopsy record books, in a dictation room connected to the

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morgue by a speaking tube, demonstrate that high standards also were set in information-collection methods.) The 160-seat amphitheater and reception rooms fostered research, education, and the exchange of knowledge among doctors with different expertise who, following the German model, had easy access to each other at the new building. Any physician from the city, many trained by lectures and apprenticeships in the mid-1850s, were invited to use the facility for continuing education.

When the Indiana legislature repeatedly failed to grant separate funding for Central State's lab, Edenharter bypassed the lawmakers and used surplus funds from the hospital's operating budget with the blessing of the Board of Control.[12] He carried the planning and building phase through to completion — apparently preferring to ask forgiveness rather than permission. The $18,000 state-of-the-art building — lauded as "the most complete of its kind in the country and one of the most complete in the world"[13] — initially had no pathologist. Edenharter apparently philosophized that "if you build it, they will come." He promoted this facility in letters to executive officers of Iowa state institutions in 1902: "I would build and equip … a department for pathological and other scientific investigations before commencing the construction of the administration building or kitchen."[14]

Photo by Norma Erickson

Ultimately, no significant advances in curing mental illness occurred at Central State. Physicians there did utilize radical treatments for insanity, including the malarial treatment of syphilis, insulin shock therapy, and pioneering work in the use of Dilantin.[15] From the use of malarial syphilis treatment, the hospital's pathologist, Walter Bruetsch, came very close to understanding the immune response several years before technology allowed it to be fully described.[16]

With the development of antipsychotic and sedative/hypnotic drugs in the mid-20th century, the need for large institutional settings for the mentally ill lessened. By the late 1960s, Bruetsch had retired, and the building was closed — but not vacated. All laboratory supplies and furniture remained. Shortly, plans calling for the demolition of all pre-1900 Central State structures materialized, with a certainty that the pathological department would be razed by the early 1970s.

In order to stop the facility's destruction, Dr. Charles Bonsett (now in his early 80s), a neurologist on the Central State faculty, formed a committee, which took steps to save one of the last examples of its type. With a methodical, sound plan and with the support of key political figures, the committee received the governor's approval to form the Indiana Medical History Museum Foundation in 1969, after which it preserved and housed Indiana's heritage of the healing arts in the Old Pathology Building.

Bonsett's zeal to preserve the building took hold in 1951, when he first attended lectures as a medical student and eventually assisted Bruetsch. His familiarity with the building allowed him in 1972 to prepare the nomination paperwork for the National Register of Historic Buildings. Before that, he forced the abandonment of demolition plans by establishing the Indiana Neurological Institute in the rear of the building and began seeing patients there.[17] With the lights and the heat still on, the roof and interior elements were maintained. When the state finally removed all financial support because Central State Hospital activities no longer existed, Dr. Bonsett personally paid the utility bills.

In November 2003, two miles from the country's oldest laboratory, ground was broken for one of the newest. Clarian Health, the merger of three city hospitals, will serve as the central laboratory for what is now the second largest hospital in the nation. The new pathology building will have its own station on a light-rail people-mover system. Included in the train's elevated tracks are tubes for the pneumatic delivery of samples to the lab from all the buildings, some of which have 1.5 miles between them. Today, the Old Pathology Building has as one of its corporate donors Clarian Health.

In today's clinical environment, maximizing resources is as much a mandate to laboratories as finding the cause of disease was 100 years ago. Just as the Edenharter lab design reflected the important values in healthcare of his time, the new design of the Clarian lab reflects today's greatest issue — the battle against the high cost of healthcare. Lab management teams have traveled to other laboratories to gain a better understanding of what works and what does not, just as Edenharter sought the wisdom of van Gieson. The issues of access and timely results are considered in the design. The Old Pathology building was begun in 1895, almost eight years before the Wright Brothers' first flight. Given the quantum leaps in technology we have experienced since then, can we imagine what the labs of today will look like to the world of 2104? □

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Note: Information for this article also came from conversations with Virginia Terpening, executive director, Indiana Medical History Museum. For more details on the Old Pathology Building, consult the museum's website at *www.imhm.org*.

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Lean lab design

Figure 1. Open laboratory plan

By Ron W. Garikes

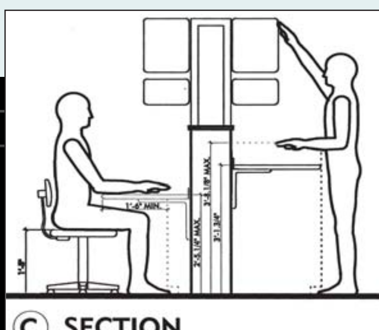
Doing more with less, re-engineering, downsizing, "right-sizing," the *One Minute Manager*, and *Who Moved My Cheese?* are all operational business models, theories, and approaches tried by a number of laboratory managers to improve best practices in their laboratories. The latest business model lab managers are considering to enhance operational efficiencies is Lean thinking, which is often combined with Six Sigma initiatives. Both of these concepts have proven to be extremely effective in manufacturing and industrial applications and are very likely to be widely accepted in the clinical lab industry. When planning lab space to accommodate Lean thinking and Six Sigma in the medical/diagnostic laboratory, certain design criteria must be considered.

First, it is important to have a common understanding of the specific goals and mission of the laboratory. The mission of most labs, in general terms, is to provide high-quality testing, quick turnaround, and superior patient/client services. These goals and objectives are commendable and worthwhile pursuits — but unattainable, in many instances, unless the lab can show consistent and sustainable cash flow and profits. Cash flow and profits can only be improved by enhancing operational efficiencies. Lean thinking and Six Sigma were created with these objectives in mind.

Lean thinking

The founders of Toyota originally created Lean thinking within the Japanese manufacturing industry. The idea was very simple and is consistent with the global business objective to do more with less. In the medical/diagnostic lab, this includes performing higher test volumes in less space with fewer full-time employees. Because of diminishing resources, including labor, material, and capital, Toyota's leadership was forced to create a production system with the primary objective to minimize the consumption of resources that add no value to the end product. The result was a production system that is now referred to as Lean manufacturing. Combined with Six Sigma, also referred to as Lean Sigma, the Lean manufacturing business model could have a profound impact on the medical laboratory industry.

Before addressing the physical space requirements to accommodate Lean thinking and Six Sigma applications, a brief review of the fundamental tenets of these business models is helpful in order to better understand the facility design implications of these approaches.



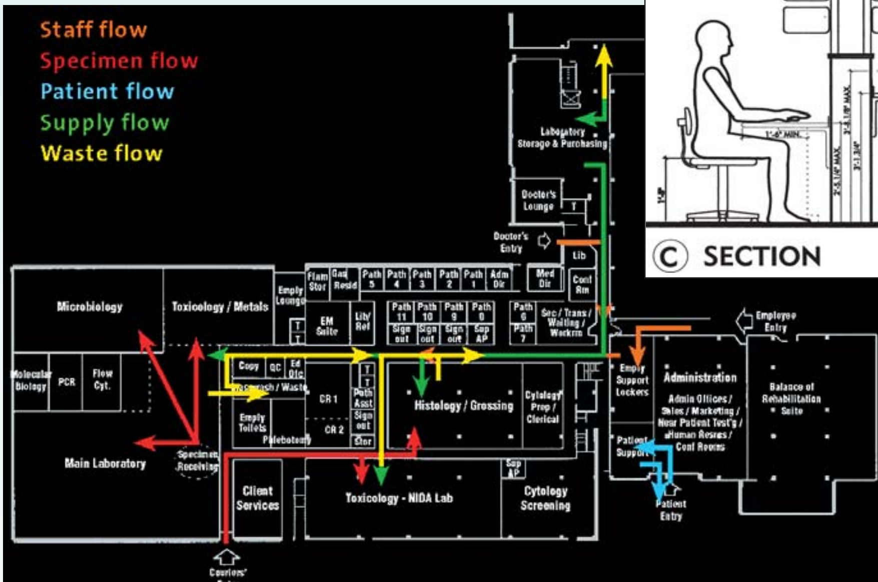


Figure 2. Ergonomic analysis (above)

Figure 3. Work flow (left)

Lean objectives

The objectives of implementing Lean thinking are:

- improve quality;
- eliminate waste;
- reduce lead time; and
- reduce total cost.

According to James P. Womack, Daniel T. Jones, and Daniel Roos in their book, *The Machine That Changed the World*, and its sequel, *Lean Thinking*, written by Womack and Jones, organizations are better able to meet customers' demands of quality, timeliness, and competitive pricing with the implementation of Lean manufacturing. Further, organizations will become more agile and efficient, improve their cost-control methodologies, and provide higher profits and greater returns to investors. One of the most important purposes of Lean manufacturing is what Womack and Jones refer to as the value stream analysis. This is a methodical approach to visually mapping the process and the "production line" with an in-depth analysis of procedural and physical steps that occur between the customer and suppliers. Lean manufacturing is also about creating an optimal flow, sometimes referred to as Lean flow. Lean flow helps create a less error-prone, cheaper, faster, and less variable supply chain.

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Another critical component of Lean thinking is to completely eliminate waste in the process. Toyota's leadership originally identified seven forms of waste that directly affect any production process. Womack and Jones, in *Lean Thinking*, identified an eighth form of waste, underutilization, which relates to the waste of substandard performance by mechanical and human resources. The eight forms of waste include:

1. overproduction;
2. waiting;
3. transport;
4. extra processing;
5. excess inventory;
6. motion;
7. defects; and
8. underutilization.

Six Sigma uses a specific set of strategies, methods, and statistics to improve a process. Steps include design, manufacturing, marketing, and customer service. Six Sigma's ultimate goal is to develop, produce, and market a new product or service that is defect free. The success of Six Sigma quality improvement methods have been well documented and effectively utilized by many Fortune 500 Companies, including GE, Sears, Motorola, and Medtronic.

Flexibility

The most important design element when planning for a Lean laboratory is flexibility. Flexibility in the lab environment is imperative to accommodating the Lean approach and Six Sigma, as constant change is critical to the success of these business models. It is also critical to create the ability to expand, modify, and completely change the functional relationships and flow within the lab. The most effective way to achieve this objective is the utilization of an open lab plan. An open lab plan allows for the flexibility of assignment of staff, the ability to share equipment/instruments, and a greater ability to effectively supervise personnel (See Figure 1).

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Expandability, adaptability, and optimal flexibility within the lab can also be greatly improved by the introduction of flexible casework. Flexible casework provides an economical and convenient method for easily modifying and configuring workstations within the lab. Work surfaces in flexible systems can be raised, lowered, added, or deleted. Base and wall cabinets can also be similarly changed. A variety of available flexible systems allow users to hang overhead cabinets, shelves, tack boards, or chalkboards that best meet the needs of their specific testing requirements. Reconfigurable partitions, integrated with flexible casework, are also available. These components are available complete with window and door openings, as desired. Viewed on an initial cost basis, maximum flexibility in casework represents a premium in the initial investment. To accommodate ongoing changes and modifications and frequent reconfigurations that will be required when implementing Lean thinking and Six Sigma applications, however, the lifecycle cost of flexible casework represents a higher return on investment and cost savings in the long term.

> *The outreach system of the future will provide all of the necessary tools to ensure the laboratory can operate in a financially viable environment.*

Utility flexibility in laboratory engineering systems, including electrical power, HVAC, lab gases, and plumbing, is a critical design consideration. According to Christopher P. Rousseau, PE, a partner with the engineering consulting firm of Newcomb & Boyd, Atlanta, GA, "Laboratory systems must be flexible to allow changes to the systems without an unacceptable impact on other lab operations. The need for flexibility, and the budget to accommodate it, must be evaluated during the systems design." Design features used to accomplish systems flexibility include ceiling plenum, layering, depth, interstitial floors, modularity, reserved riser space, and accommodations for future capacity and/or systems. Rousseau further states, "Individual laboratory control panels, lab piping, isolated valves, and the strategic layout of other system distribution components are also ideal ways to provide additional flexibility and adaptability within the lab."

Workstations

Another important design consideration when designing Lean lab space is to focus on the development of individual workstations. Workstations, simply stated, are the specific places within the lab that are used to prepare, perform, or report test results. The number, size, instrumentation, location, and specific functions of a workstation are the basis for many planning and design decisions that have to be considered when implementing a Lean process. If a specific Lean tenet is to create a greater volume of specimens being processed more efficiently and in a smaller area, a wider variety and larger number of smaller, more efficient workstations may be necessary. A thorough analysis of ergonomic considerations within the workstations, including bench-top heights, location of kneeholes and drawers, and the location of bench and floor-mounted instrumentation are all critical design issues that must be

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thoroughly evaluated to enhance the Lean approach (See Figure 2). Once all the workstations have been identified, defined, and "right-sized" for a Lean process, optimal space requirements can be projected for the entire laboratory.

Work flow

Work-flow analysis and the development of optimal adjacencies within the laboratory and between workstations are also critical design criteria. Similar to the methodology of value stream analysis and consistent with this approach, a thorough analysis of the work flow within the lab supports this value-added process and the elimination of waste, which are cornerstones of Lean thinking. Specific flow patterns for specimens, staff, patients, supplies, and waste should be thoroughly evaluated. As Lean thinking was developed with a specific emphasis on adding value to the process and eliminating waste, it is imperative to thoroughly test and validate the flow within the lab to achieve optimal efficiencies. Animated, computerized flow diagrams graphically depicting work flow within the lab are ideal planning tools for analyzing and creating optimal flow scenarios. Figure 3 shows an example of a typical flow diagram for a generic central core lab serving a multihospital system.

Another critical component of Lean thinking is to completely eliminate waste in the process.

Lean opportunities

The ability to readily accommodate Lean thinking, Six Sigma, and other new operational business models will give any laboratory a competitive advantage in this ever-changing and increasingly demanding industry. Designing for flexibility, either within the restraints of an existing lab or for a new facility, is the key to successfully integrating Lean thinking in the lab environment.

The opportunity to achieve a healthier bottom line can be significantly impacted by the introduction of Lean thinking and Six Sigma. The design of a flexible lab environment, utilizing an open plan, combined with the development of "right-sized" workstations, efficient flow, and optimal adjacencies will further position a laboratory to take full advantage of the many opportunities created by Lean thinking. □

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