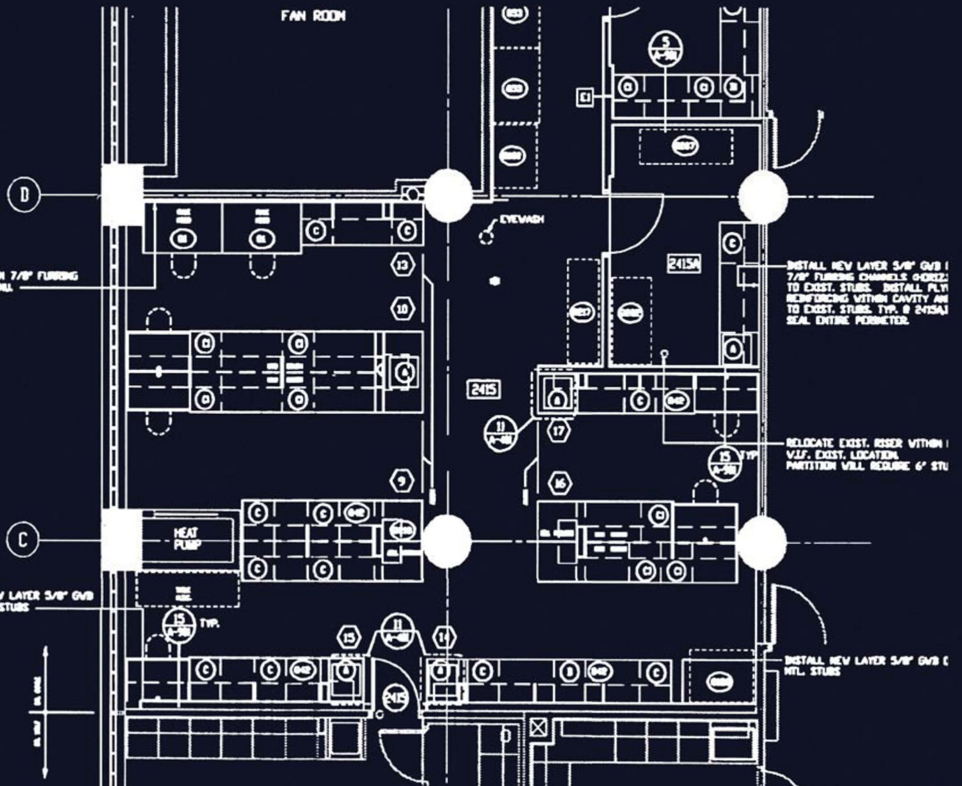
Laboratory Design Handbook

E. Crawley Cooper



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CRC Press
Boca Raton Ann Arbor London Tokyo

Library of Congress Cataloging-in-Publication Data

Cooper, E. Crawley.
Laboratory design handbook / E. Crawley Cooper.
p. cm.
Includes bibliographical references and index.
1. Laboratories—Design and construction. I. Title.
TH4652.C66 1994
727'.5—dc20 93-44971
ISBN 0-8493-8996-8

Direct all inquiries to CRC Press, Inc., 2000 Corporate Blvd., N. W., Boca Raton, Florida 33431.

International Standard Book Number 0–8493–8996–8
Library of Congress Card Number 93–44971

Preface

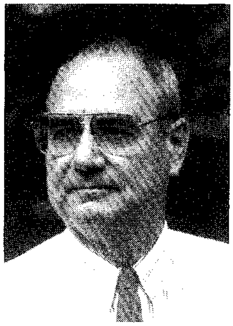
This book is intended to assist those involved with creating new laboratories, remodeling existing laboratories or adapting an existing building to become a lab. Architects, engineers, scientists, facility managers, lab administrators, code officials, insurance underwriters, construction managers and builders may find it contains useful information. We have attempted to describe the process, motivation, constraints, challenges, opportunities, and specific design data related to the creation of a modern research laboratory facility. It is a reality that much of the information contained in this text will be completely outdated within a decade due to the rapid changes taking place in the sciences.

It is based on a large pool of experience in the development of new and renovated laboratory buildings for universities, teaching hospitals, pharmaceutical companies, start-up biotechnology companies and other types of industrial technology.

I am indebted to many people in gathering this information. Harry Orf, an organic chemist with the Massachusetts General Hospital in Boston and a Principal in Cambridge Laboratory Consultants, shared his knowledge with us when the MGH Lawrence E. Martin Labs in Charlestown, Massachusetts were under design. His partner at Cambridge Laboratory Consultants, Donald J. Ciappenelli, was kind enough to perform the technical review for this book. He made many valuable suggestions during that process. Robert Hsiung, a colleague at Jung/Brannen Associates, Inc., and designer of many outstanding laboratory facilities gave us some valuable insight into the design process. Richard G.

Burnham of Dick Burnham Technical Sales and David Lupo of B & V Testing, Inc. contributed their valuable comments on the intricacies of lab equipment. Bruce MacRitchie of MacRitchie Associates, Inc. and Mike Zimmerman of Zimmerman Consulting contributed their engineering perspective. William Watson helped with advice related to the chapter on animal facilities. Ronald Prachniak, Corporate Projects Director at Massachusetts General Hospital, provided valuable insight on a wide range of research related issues.

The illustrations relating to chemical fume hoods and biological safety cabinets are reprinted by permission of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Georgia, from the 1991 ASHRAE *Handbook–HVAC Applications*.



E. Crawley Cooper, AIA, earned his BS in Architecture at the University of Cincinnati and his Master of Architecture degree from the Massachusetts Institute of Technology. His current position is as Principal, Jung/Brannen Associates, Inc., in Boston, Massachusetts, and his previous experience was as Associate with Pietro Belluschi and Eduardo Catalano in Cambridge, MA; as Chief Designer with James Associates of Indianapolis, IN; and as Architect with Anderson Beckwith and Haible in Boston, MA. Mr. Cooper has served as Lecturer at the Massachusetts Institute of Technology, the Harvard Graduate School of Design, Purdue University, the University of Wisconsin, and at the Recombinant DNA Research Laboratory of the National Institutes of Health in Bethesda, MD.

In addition to directing numerous laboratory projects, Mr. Cooper has headed or been a member of groups such as school building committees, a long-range planning committee, a town planning board, a planning task force, and a rezoning study committee. He has also acted as Consultant for Arthur D. Little, Inc., at the United Nations Conference Center in Vienna, Austria.

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Laboratory Design Handbook

Introduction

Firmness, commodity, delight: the three elements of architecture according to the great Roman architect and teacher, Vitruvius. This book has little to do with firmness or delight. It is mostly about commodity, or function, of the buildings where scientific research is conducted.

Modern research facilities provide usable space for laboratories, lab support areas, offices, and interactive spaces for formal and informal gatherings. The special equipment and environments required for research make these buildings extremely complex. A successful lab must also provide a safe and humane place for people to work. A well designed laboratory can be a significant tool for recruiting the best minds available. It can encourage the sharing of ideas in a culture that seeks the truth with an interdisciplinary team approach. And, laboratories are expensive facilities to build and operate.

The pace of discovery and the potential hazards of research have dictated that sophisticated mechanical and electrical systems and services are available to create pleasant, productive, and safe environments for scientific inquiry. It is not unusual for the building volume devoted to systems and services to exceed the usable, or served spaces. The relationship between the service volumes and served volumes in a laboratory facility is of paramount concern to the designer. However, a machine-centered design approach must be tempered by an understanding of how teams of researchers work and interact with each other and their environment.

The research scientist and the architect play complementary roles in the design process that results in a successful new laboratory. Generally, scientists are concerned with the micro scale. Studying a system's components in minute detail under a microscope is how they excel. Scientists are used to dealing with specifics; being precise is second nature to their culture. Things need to be quantified!

Architects, on the other hand, have been trained as generalists. Initially, they are inclined to look at the big picture. How will the project interact with the community, the available infrastucture, the environment? How will the laboratory users interact while performing their tasks? How can the proposed facility enhance and contribute to research? These questions are paramount to generalists. Issues need to be qualified and priorities established!

Before attempting to initiate a design concept, the scientists should prepare a mission statement about their work. What are their goals? How will they be achieved? Who will contribute in the achievements? What is the image for the facility? Identify the constraints. This exercise will help the research institution establish priorities and communicate among themselves and with their architect.

The architect should not have preconceptions about laboratory design. Often the best ideas for design concepts come from the building's users. The talented designer will listen to the mission statement for ways of creating opportunities out of challenges. Innovative concepts should be explored at both the micro and macro scale as a collaborative effort between the research scientist and the architect. By nature, many of the activities that occur in a laboratory setting are on the cutting edge of technology. The development of new and better processes and discoveries is the goal of research. Change, then, is inevitable over time. This establishes adaptability as a virtue for the lab facility.

Many research laboratories are developed around modular concepts that can provide maximum flexibility with a minimum of underutilized investment. The key ingredient is to provide appropriate structural volume arranged in a modular way that can accommodate a wide range of mechanical and electrical environmental systems.

Control of the environment is crucial to the success of scientific research. Over half of a "wet" lab facility construction costs are devoted to the mechanical and electrical systems. ("Wet" labs are defined as those labs with pure water and chemical fume hoods.) These systems contribute to the safety, reliability, efficiency, and productivity of the research work.

A generous vertical floor-to-floor dimension is essential for pharmaceutical or biological research laboratories in order to provide adequate space for the horizontal mechanical and electrical distribution systems. These systems can be placed above a suspended, accessible ceiling or within a dedicated interstitial service floor sandwiched between alternate laboratory floors. Either arrangement can be applied to a number of plan options. Obviously, the interstitial services floor concept is more costly, but it provides good long-term adaptability and a more efficient maintenance program. The Office of Management and Budget (OMB) under recent federal administrations would not permit federal funding for the interstitial floor concept because of the high initial cost premium for the larger building volume.

Wet labs consume staggering amounts of energy. In fact, they are energy "monsters."(One six-foot fume hood requires 1,100 to 1,200 cfm of 100% fresh, conditioned air 24 hours/day, year-round.) Strategies for reducing energy consumption include variable air volume (VAV) systems for the building and hoods, heat recovery techniques, such as plate exchangers and heat wheels, electronic direct digital automatic controls (DDC). Unfortunately, these relatively sophisticated measures only make a small dent in reducing operating costs and energy consumption.

Funding for research is expected to continue and grow over the next decade. In 1992, federal funding from the National Institutes of Health totaled 7.3 billion dollars. According to the Boston Redevelopment Authority, over the next ten years the medical research institutions in the Boston area alone will add an estimated 2.6 million square feet of research space and employ an estimated 3,100 to 5,500 new scientists and support staff.

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