

## Lighting Design Considerations in Biomedical Research Facilities

### Introduction

Lighting in biomedical laboratories has evolved over the years to meet energy code requirements and to accommodate flexible lab designs with advanced digital capabilities. A laboratory might need different types of spaces such as collaboration and innovation spaces, data analysis and documentation spaces, and typical wet and dry lab spaces. Lab lighting design must therefore address the various illuminance levels needed for all these spaces while also addressing important visual factors. A layered lighting system approach can meet these needs and align with the architectural design, while advancements in energy efficient technology such as Light Emitting Diode (LED) fixtures and integrated lighting controls aid in meeting energy codes.

### Visual Factors

The primary factor in lab design is typically illuminance. However, difficult visual tasks are performed in biomedical labs, and failing to account for this in lighting design can lead to eye fatigue, poor visibility, and an uncomfortable working environment. Designers must therefore also consider the following visual factors:

1. Uniformity
2. Glare
3. Shadows
4. Surface Brightness
5. Vertical Surface Illumination

Appropriate fixture placement that accounts for these factors will result in improved lighting and productivity of lab personnel.

### Additional Factors

Another important factor for successful lighting design is the selection of appropriate finish colors for the floors, walls, and ceiling. The lighting designer must work closely with the architects and interior designers to provide a workspace that facilitates innovation and collaboration while reducing eye fatigue.

Color temperature of lamps should be chosen based on the type of work performed. A future article will explore various color temperatures and their application.

The lighting quality perceived by individuals is very subjective based on their preferences and age. As humans age, most need higher light levels to perform visual tasks. The lighting designer should seek information about the occupants in the lab space and the types of visual tasks to be performed there.

### Layered Lighting Design

As the name implies, a layered lighting design approach uses overhead lights combined with task lights to meet required lighting levels while addressing the visual factors. In this approach, the ambient lighting from ceiling mounted (direct, indirect, or combination) light fixtures provides lighting levels adequate for circulation within the lab. Energy efficient task light(s) integrated with casework can provide higher illuminance levels required on the bench top, where difficult visual tasks are performed. If flexible casework is planned, lighting power sources should have flexible connectors while meeting National Electrical Code requirements; many casework vendors incorporate task lighting in their modular design, which enables changes to lab layout without intrusive major renovation.

### Integrated Lighting Controls

Lighting control technology has improved significantly with the development of occupancy sensors, daylight sensors, and centralized controls. Occupancy sensors played a major role in energy savings during the pandemic since occupancy in most spaces dropped to as low as 25%. Systems using occupancy sensors can be standalone or integrated with building controls; whichever is chosen for the project, the designer must ensure the system is user-friendly so that lights are controlled per design intent and planned energy savings can be realized. Lighting controls and systems should be commissioned to ensure they perform as designed, and users and maintenance personnel should be trained in proper operation and maintenance.

### Summary

Thoughtfully designed, layered lighting systems in laboratory spaces can support research needs and a flexible architectural design. In addition, properly commissioned lighting control systems, paired with daylighting (when appropriate), can increase researchers' eye comfort and productivity. Effective, efficient lighting design will account for a variety of factors and make best use of available technology to support the activities that take place in a space.

### Additional Reading

1. NIH Design Requirements Manual - Chapter 10 Section 10.7
2. Lighting laboratories: Design Challenges  
<https://www.labmanager.com/lab-design-and-furnishings/lighting-laboratories-design-challenges-23433>
3. Thoughtful Lighting for modern labs  
<https://www.arup.com/perspectives/lighting-in-extreme-laboratory-environments>

