LIGHTING IN THE VIVARIUM; THE SPECTRUM AND INTENSITY IS CRUCIAL; THE SOURCE IS NOT

Ocular Toxicology Specialty Section Webinar
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GOALS OF THE PRESENTATION

- To Provide
  - A primer on illumination terminology
  - A review of the guidances on vivarium and workplace lighting
  - An explanation of light measurement technology
  - How to evaluate of lamp spectral outputs
  - Recommendations for vivarium lighting for both animal health and worker safety and productivity
  - Resources for evaluating vivarium lighting
  - A lively discussion

THE TECHNICAL TERMS

- Lamp: The light-emitting source
- Emission Spectrum: Plot of emitted radiant power vs. wavelength of a light source
- Lux: Unit of visible light per unit area
  - This is the most common light measurement unit used
  - Based on human vision
- Correlated color temperature (CCT): The measure (in Kelvin degrees) of the color of a light source
  - Warm white (~3000 K) cool white (~4000 K), and daylight (~6500 K) are three common CCT for commercially-available lamps

WHAT IS CRITICAL

- Spectral Distribution
  - What determines the ‘color’ of the light
- Intensity
  - How bright is the light

Spectral Distribution and Intensity Measurement

- Spectroradiometry: Light intensity at each wavelength
  - Spectroradiometers are relatively to very expensive and generally not required for routine workplace evaluation
  - The technical specifications supplied with the lamp should include the spectral distribution of the light output. If not included, don't use them.
- Radiometry: Measurement of visible light
  - Relatively inexpensive radiometers/detectors are available and are simple to use
- For a GLP facility, ensure that any 21 CFR Part 11 compliance issues are addressed

THE IMPETUS TO CHANGE TO LED LAMPS

Energy conservation, efforts to reduce carbon footprint and cost savings are pushing the change to LED lamps

- Do not require ballast starters
- Are much more energy efficient
- Are long-lasting, reducing labor to monitor and change lamps
- Generate little heat, saving environmental control costs
- Are configurable in limitless shapes
- Price is decreasing
- Are available in more and more spectral distributions (light colors)
- Are not hazardous waste

TWO GUIDANCES FOR ANIMAL ROOM LIGHTING

- Guide for the Care and Use of Laboratory Animals. National Research Council, Institute for Laboratory Animal Resources Commission on Life Sciences, National Research Council (8th edition, 2011)

- Guidelines on the Care of Laboratory Animals and Their Use for Scientific Purposes. The Royal Society of London, Universities Federation for Animal Welfare (1987)

WHAT IS NOT ADDRESSED IN THE GUIDANCES

- Spectral distribution/wavelength to use
- Lamp type(s)
- Lighting for effective worker performance

WORKPLACE LIGHTING

Falls under task lighting in various industry standards and governmental regulations

- US Occupational Safety and Health Administration (OSHA)
- American National Standards Institute (ANSI)
- Canadian Center for Occupational Health and Safety (CCOHS)

All recommend specific lux levels for laboratory work dependent on the type of work performed (and a lot of other work places)

MISCONCEPTIONS ABOUT THE RISK OF LED LAMPS

- Confusion about potential adverse effects of light was directed toward the LED lamp itself, not the emitted light
  - Reports in the popular press about perceived LED ocular damage to human and pet eyes
    - Lacking in scientific rigor
  - References back to 1997 on potential LED eye hazard (e.g., Sliney, DH, Optics and Phonics News)
  - Literature that pointed to laboratory animal ocular damage caused by LED lighting

ONE TRIGGER FOR WIDESPREAD CONCERN ABOUT VIVARIUM LED LIGHTING

- Krigel, *et al.* Light-induced retinal damage using different light sources, protocols and rat strains reveals LED phototoxicity. Neuroscience 229:296-317, 2016.
  - Identified the blue component of the ‘cold white’ LED (6300 K) spectrum as a cause of retinal phototoxicity
  - Notice how the title is misleading
- This and other reports raised concerns about LED-emitted light
  - But often the primary focus was on the lamp, not the emitted spectrum

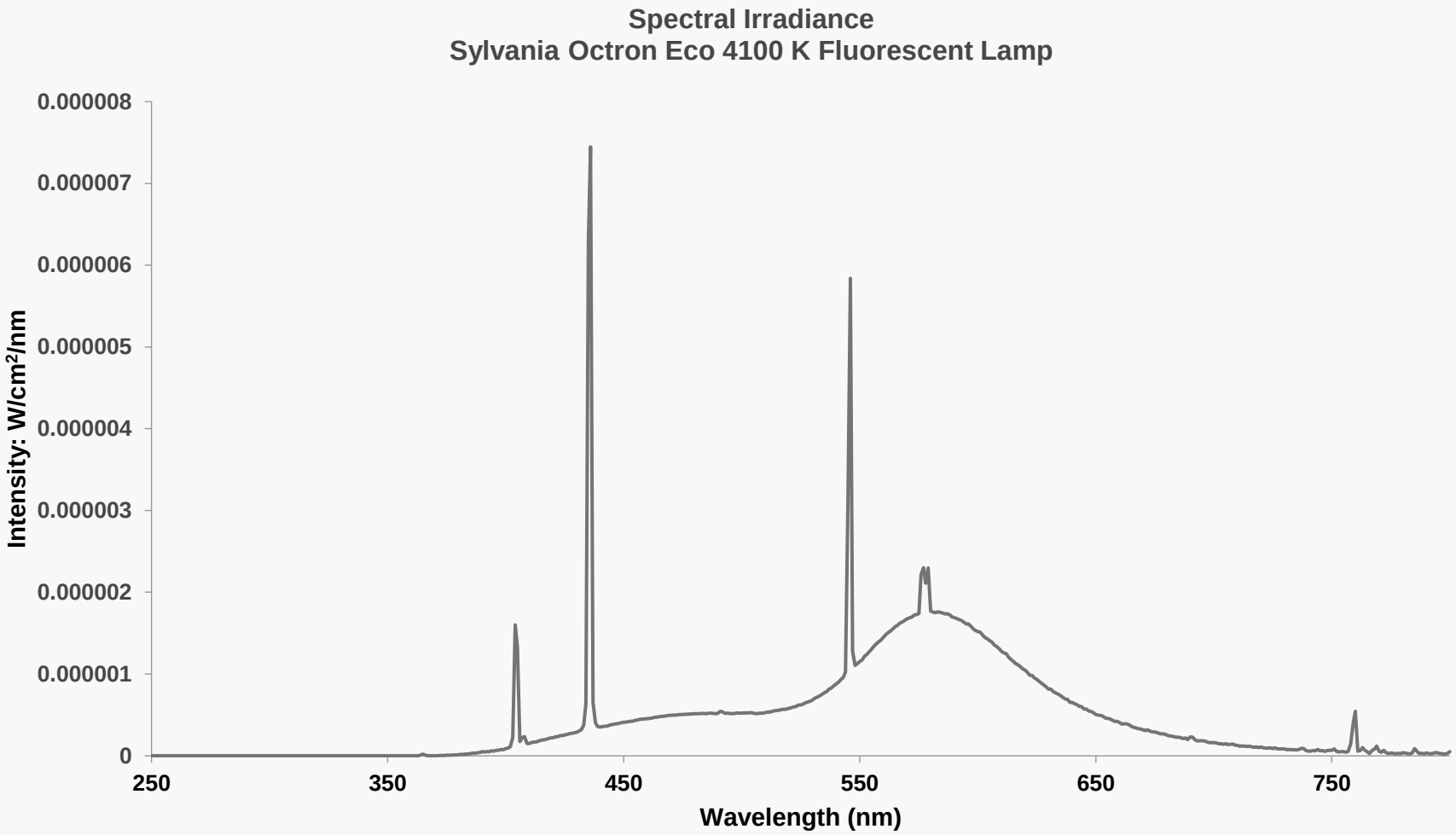
BUT WHAT IS THE RISK IN A VIVARIUM?

- Remember the majority of laboratory animals (i.e., rats, mice) are nocturnal or crepuscular and adapted to low light levels
  - Lighting is primarily for worker function and safety
- The primary physical risk is retinal damage in **albino** rodents primarily due to the absence of dark repair
  - The risk is based both on intensity and spectral distribution/wavelength
  - Both can be addressed with engineering controls and lab practices
  - **But, it is the light, not the lamp that emits the light**
- I will not address photoperiod or other light topics; e.g., zoo lighting, large animal laboratory lighting, mixes of natural and artificial lighting, lighting effects on behavior

HOW TO EVALUATE LIGHT SOURCES

- First is spectral distribution

FLUORESCENT LAMP



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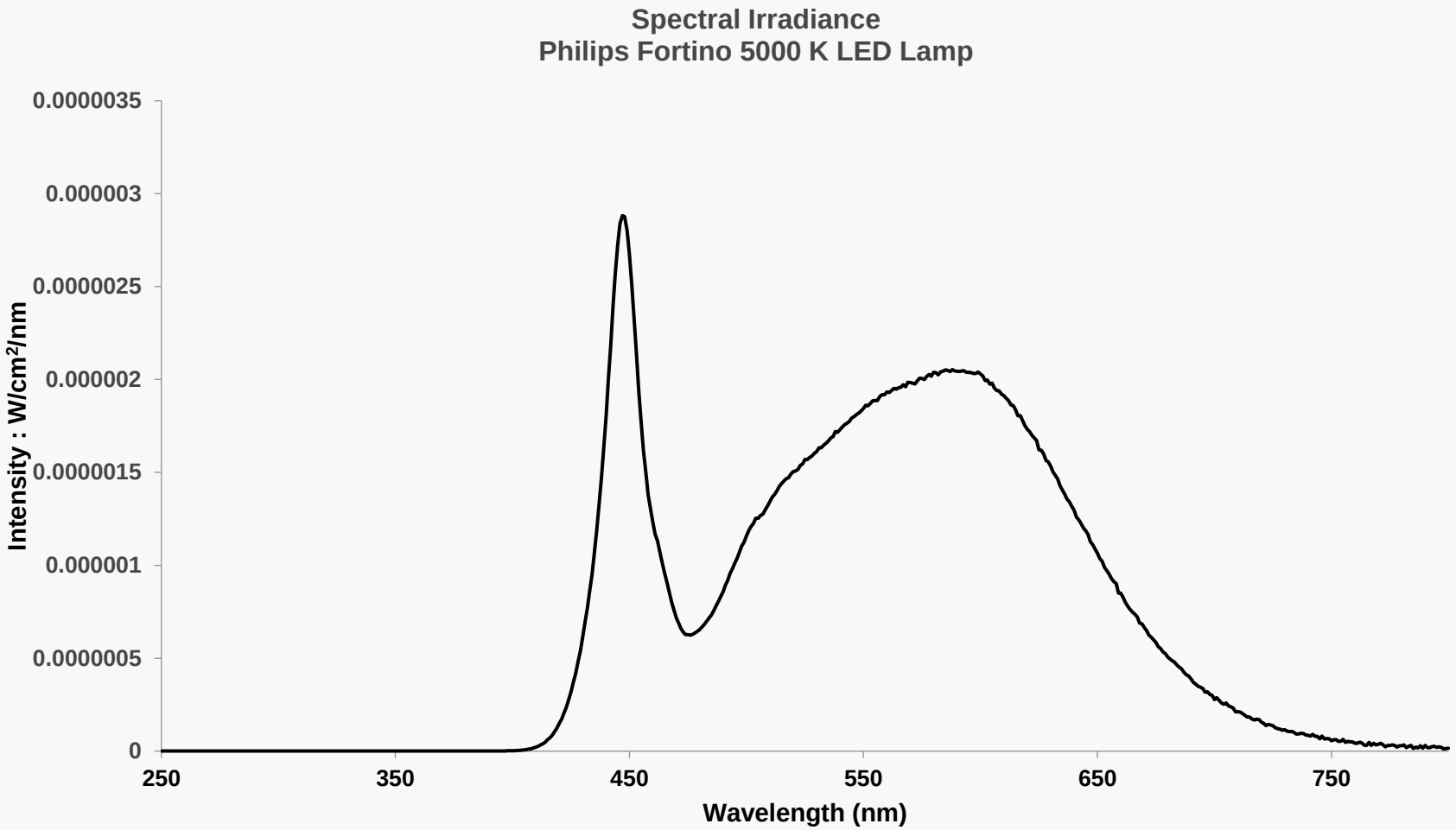
5000 K LED LAMP



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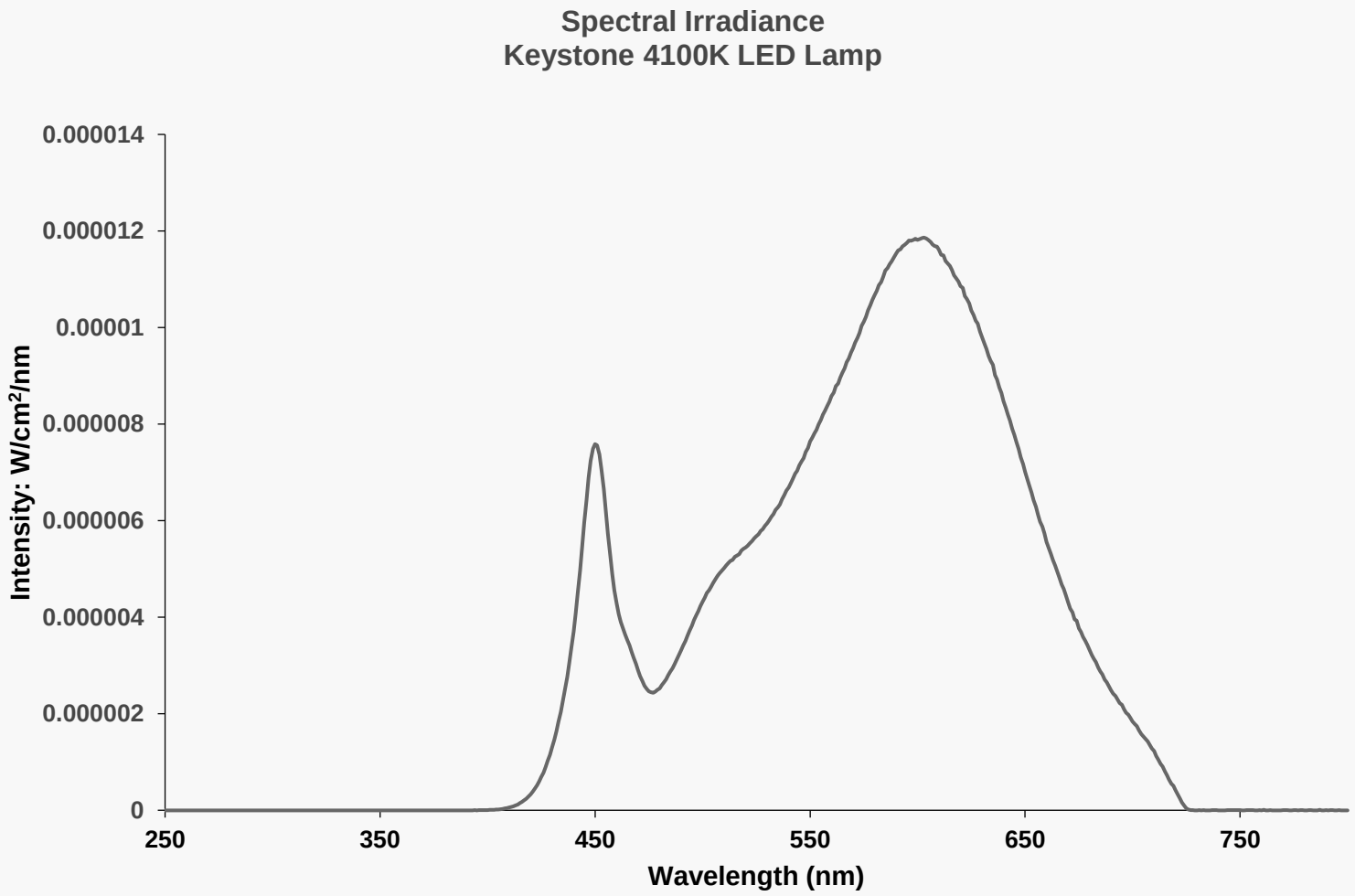
4100 K LED LAMP



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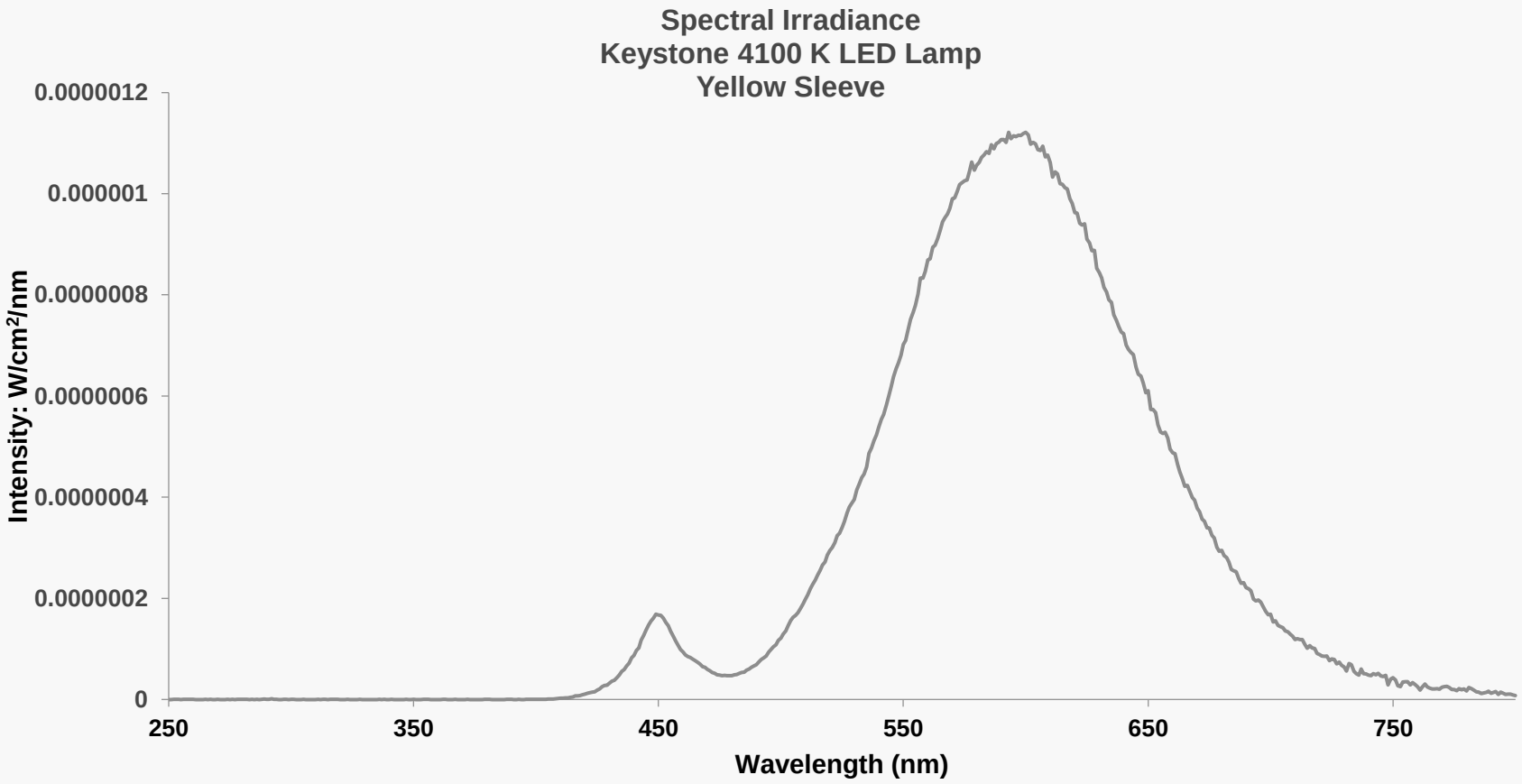
GOLD FILTERED LED LAMP



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SECOND IS LIGHT INTENSITY

- Radiometer and visible light detector
  - Common reported units are lux, foot candles, watts/cm^2
  - Ensure the radiometer is calibrated to NIST-tracible standards and measure the entire visible (photopic) spectrum
  - Keep the unit calibrated as per manufacturer's specifications
  - Ensure the spectral sensitivity of the meter matches the spectral output of the light
  - Remember that the meter is not sensitive to the type of lamp emitting the light, only the light is being emitted

BEST LABORATORY PRACTICES

- Lamps emitting color temperature of 3000 K to 4100 K
- Intensity of no more than 400 lux in the center of the study room
- Lamp placement is crucial for even light distribution in the room
  - Minimize ‘hot and cold spots’
  - Vertical caging rotation to prevent retinal photodamage in long term albino animal studies
- Use spot lighting for procedures that require high worker visual acuity

POINTS TO REMEMBER

- The light color temperature and intensity is important, the lamp that emits the light is not
- Covers/diffusers on the lamp fixture normally will not affect visible light spectral distribution
- Know/trust your lamp supplier
- Review the lamp specifications to ensure that they meet specification
- Reach out to lighting experts when constructing/renovating facilities

FOR MORE INFORMATION

- Lamp manufacturer websites
- Governmental regulations
- Industry standards
- Illuminating Engineering Society (www.ies.com)
- Lighting suppliers
- Architectural firms/workplace designers
- Internal energy conservation resources

AND REMEMBER

- The Spectrum and Intensity is Crucial, the Source Is Not

THANK YOU FOR YOUR ATTENTION

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