

Smart Lighting

The Right Light where and when you need it

Partha S. Dutta

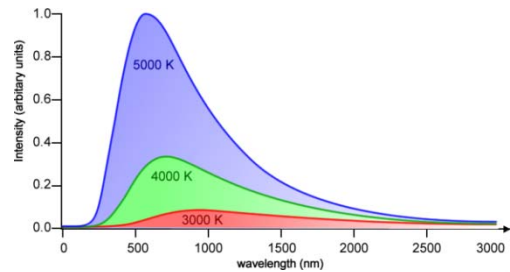
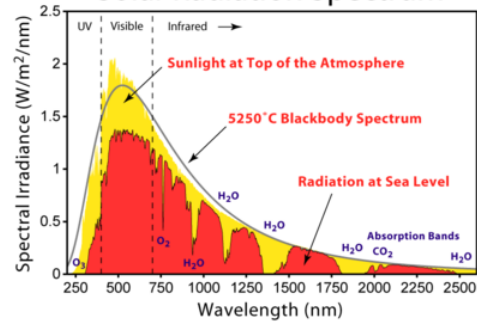
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Electrical, Computer and Systems Engineering
Rensselaer Polytechnic Institute, Troy, New York, USA
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July 7th, 2010

Light Sources



Solar Radiation Spectrum



Increasing Wavelength →

← Increasing Frequency

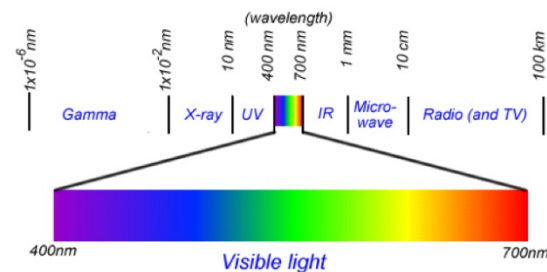
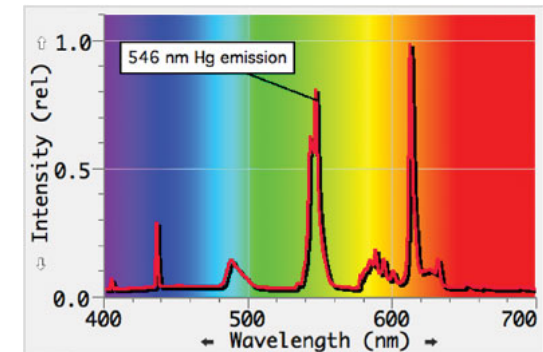
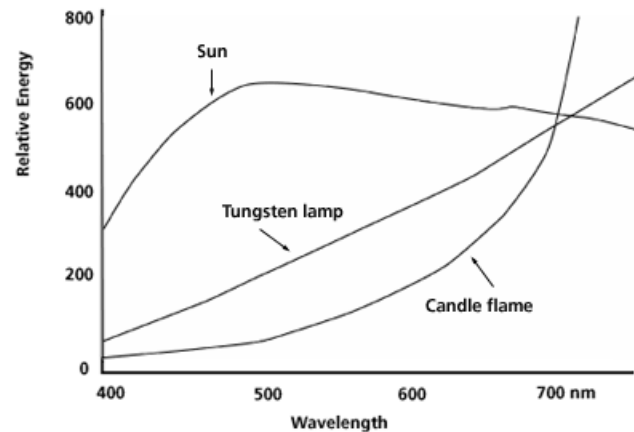
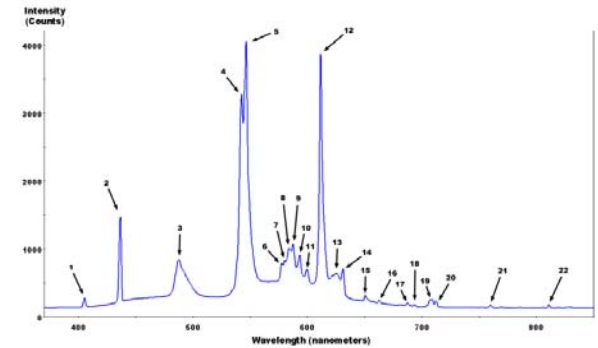
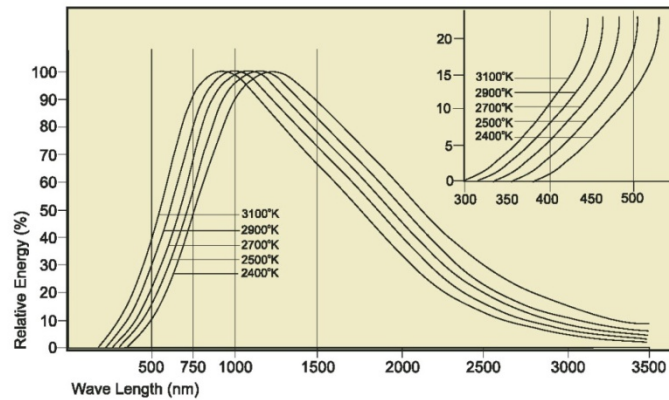
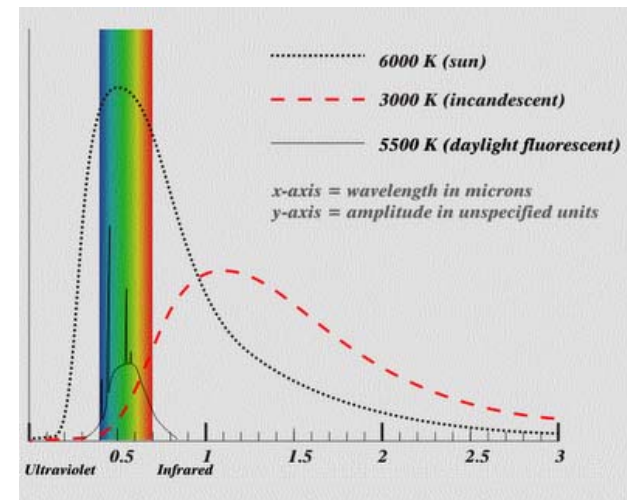
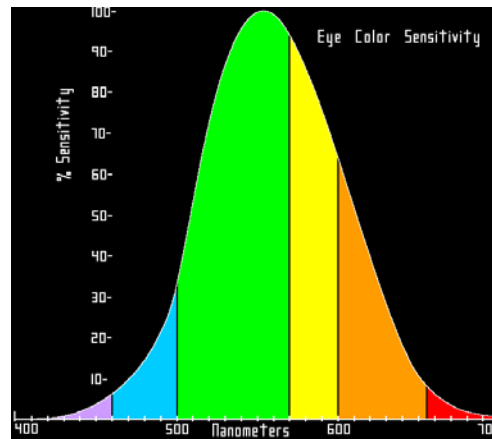
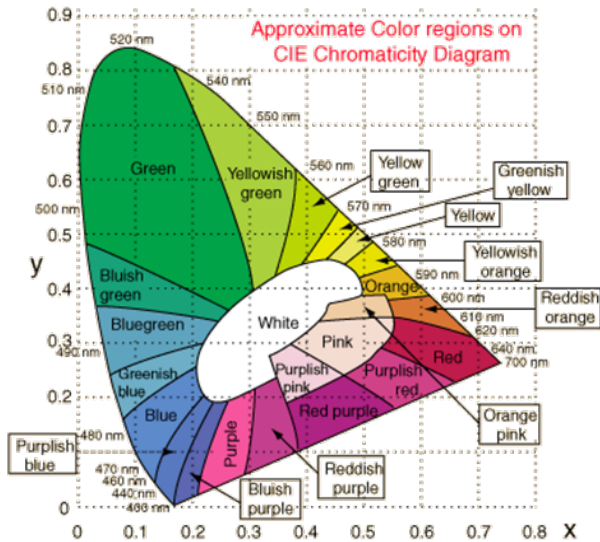
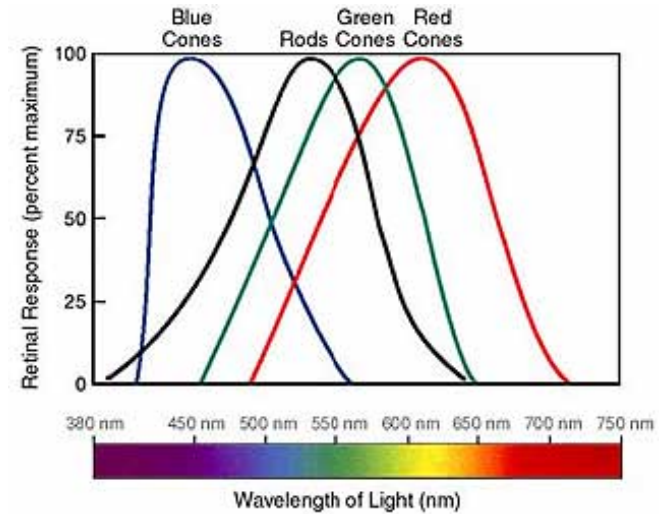
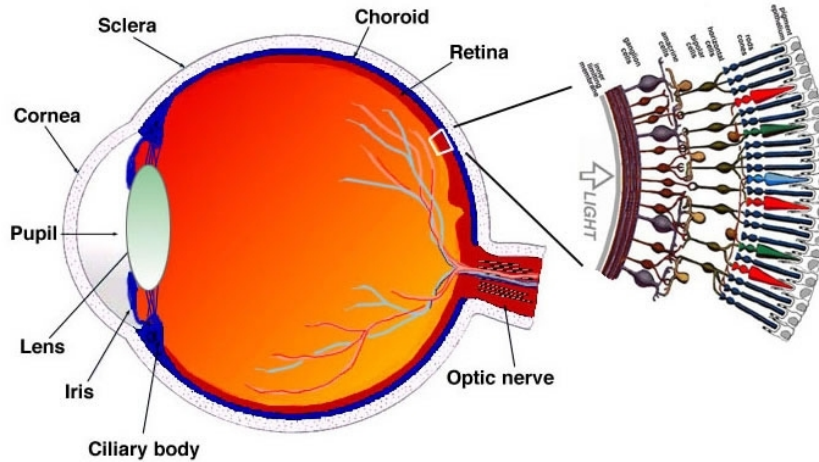


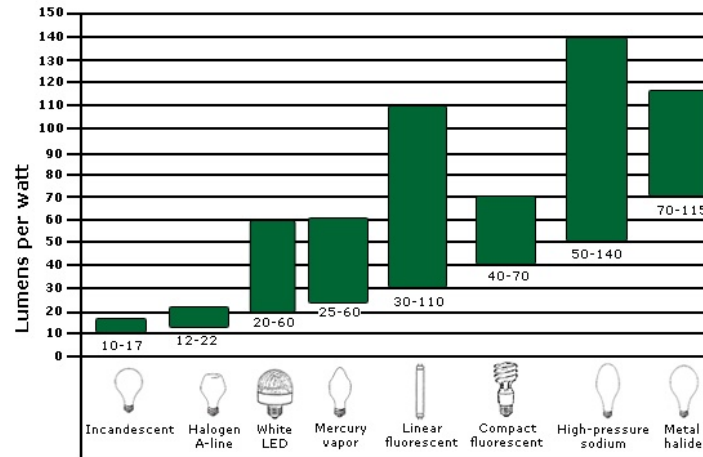
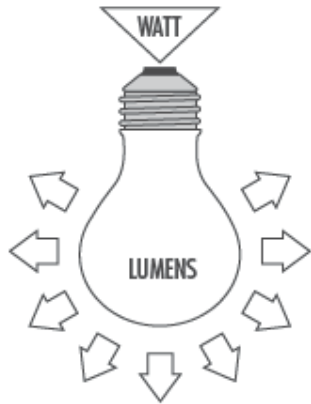
Figure 2: Spectral Radiation Output for Tungsten Filament Lamps (Including Halogen Lamps & Technical Lamps).



Human Eye



Efficiency of Light Sources



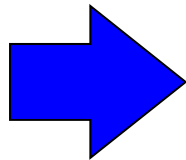
Category	Lumen/watt
Incandescent	10 to 35
Mercury Vapour (HID))	20 to 60
Light Emitting Diode	100 (today) 200-300 (Future)
Fluorescent	40 to 100
Metal Halide (HID)	50 to 110
High Pressure Sodium (HID)	50 to 140
Low Pressure Sodium	100 to 180

Emergence of Digital Lighting Technologies

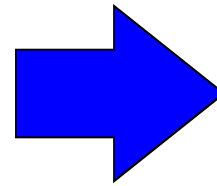
- Solid State Light sources: inherent spectral, polarization, spatial emission, temporal, color temperature controls, compact foot print, integration with microelectronics



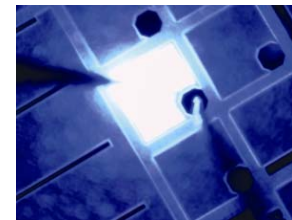
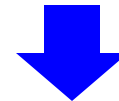
**Conventional
Lighting: poor
efficiency, no
controllability**



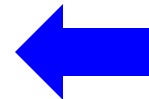
**High Efficiency
No controllability**



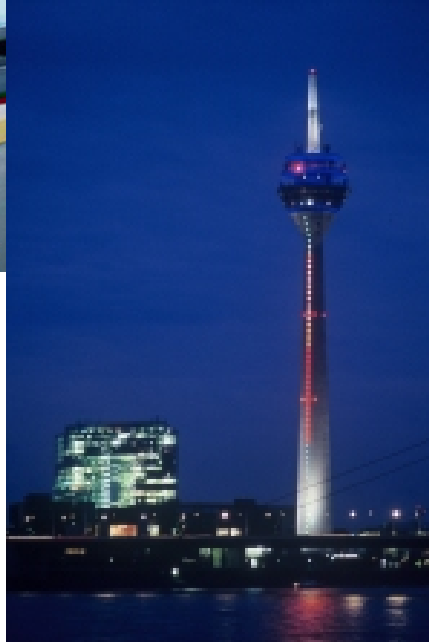
**Efficiency &
Controllability**



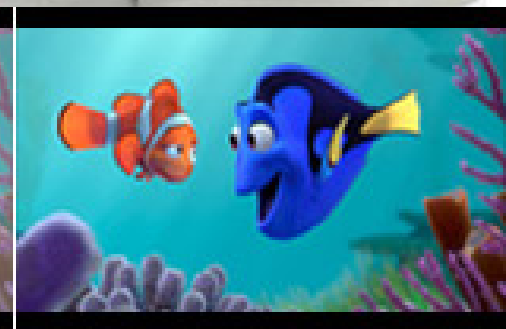
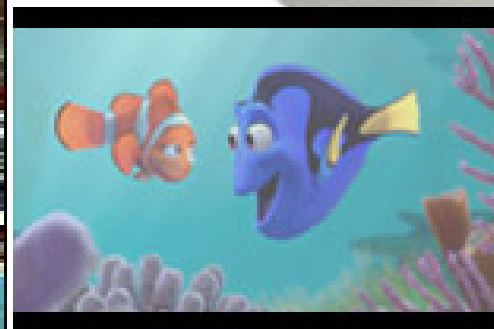
High Optical Flux



Smart Lighting

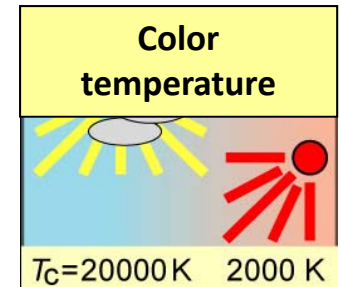
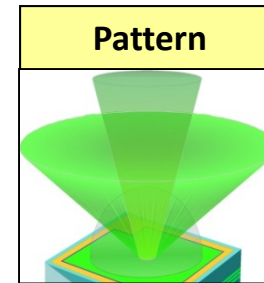
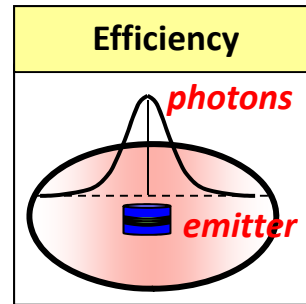
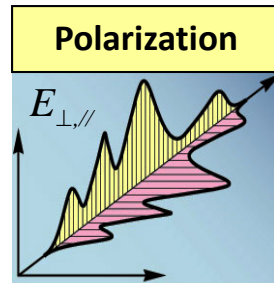
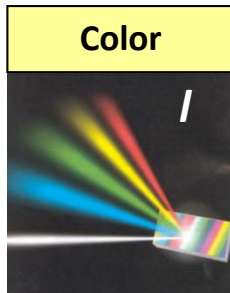
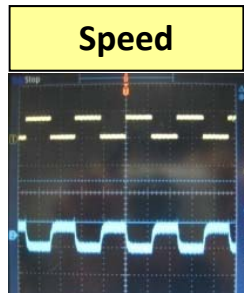


Solid State Lighting & Displays

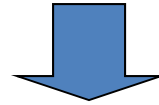


Conventional Television

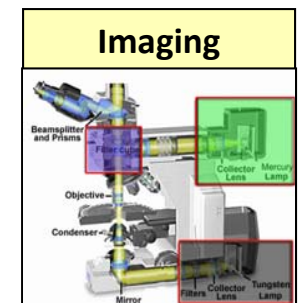
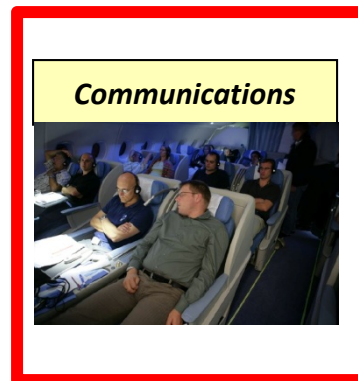
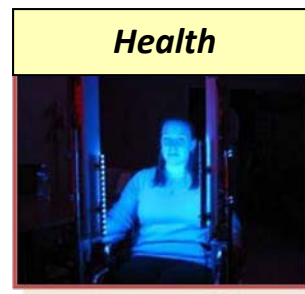
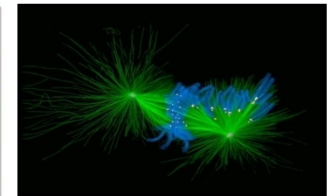
Smart Lighting Systems



Digital Light Sources



Smart Systems



Need for Large Scale Artificial Lighting



The **RISE** of **VERTICAL FARM**S

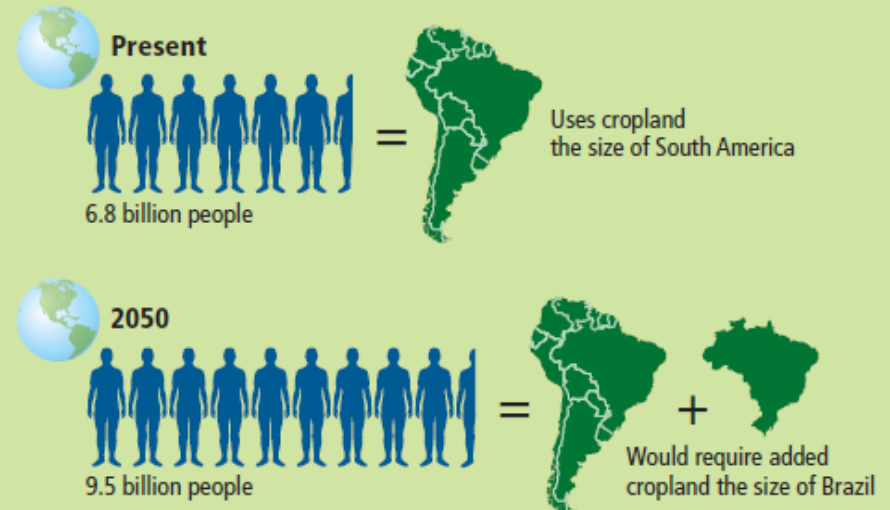
Growing crops in city skyscrapers would use less water and fossil fuel than outdoor farming, eliminate agricultural runoff and provide fresh food

By **Dickson Despommier**

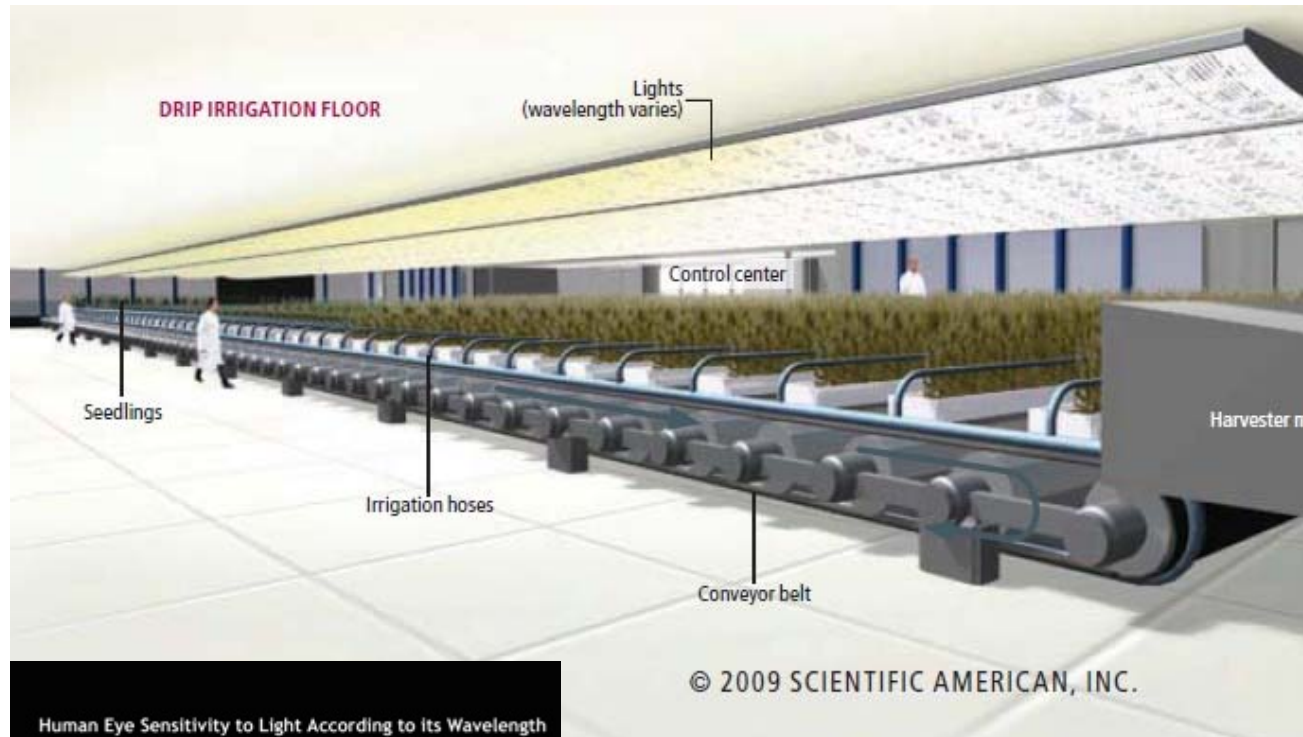
[PROBLEM]

Feeding the Future: Not Enough Land

Growing food and raising livestock for 6.8 billion people require land equal in size to South America. By 2050 another Brazil's worth of area will be needed, using traditional farming; that much arable land does not exist.



Large Scale Deployment of Smart Light Sources

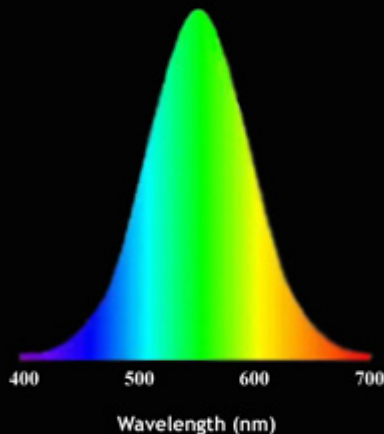


High-Rise Crops

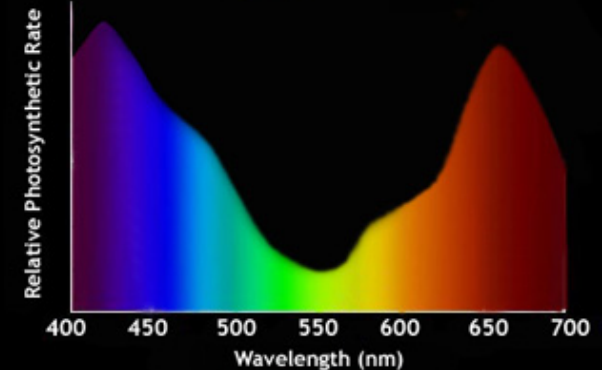
A 30-story vertical farm would exploit different growing techniques on various floors. Solar cells and incineration of plant waste dropped from each floor would create power. Cleaned city wastewater would irrigate plants instead of being dumped into the environment. The sun and artificial illumination would provide light. Incoming seeds would be tested in a lab and germinate in a nursery. And a grocery and restaurant would sell fresh food directly to the public.



Human Eye Sensitivity to Light According to its Wavelength

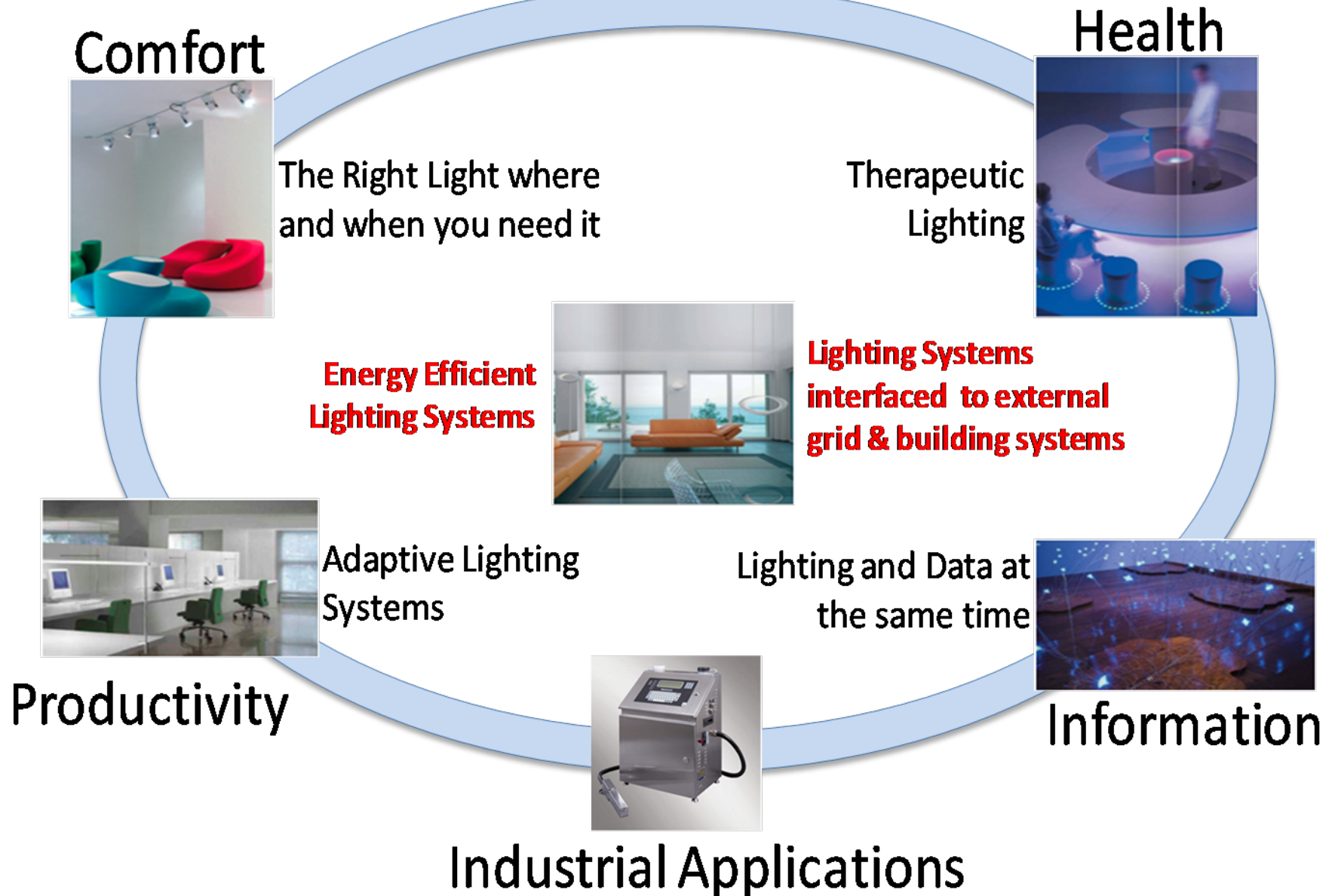


Photosynthetic Action Spectrum



Wavelength Controlled Plantation

Smart Lighting Transformation



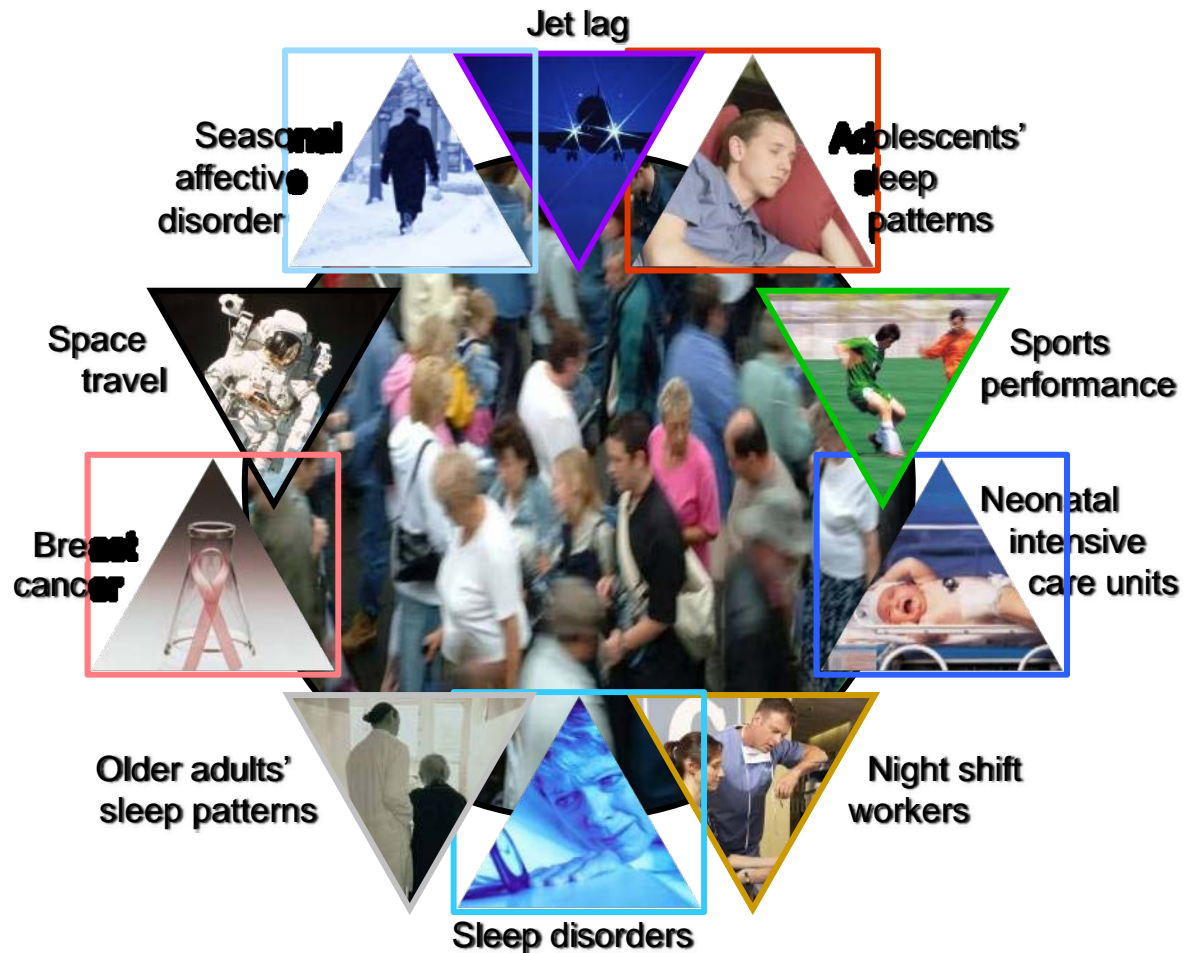
Light and Human Health

- Light isn't just for vision anymore!

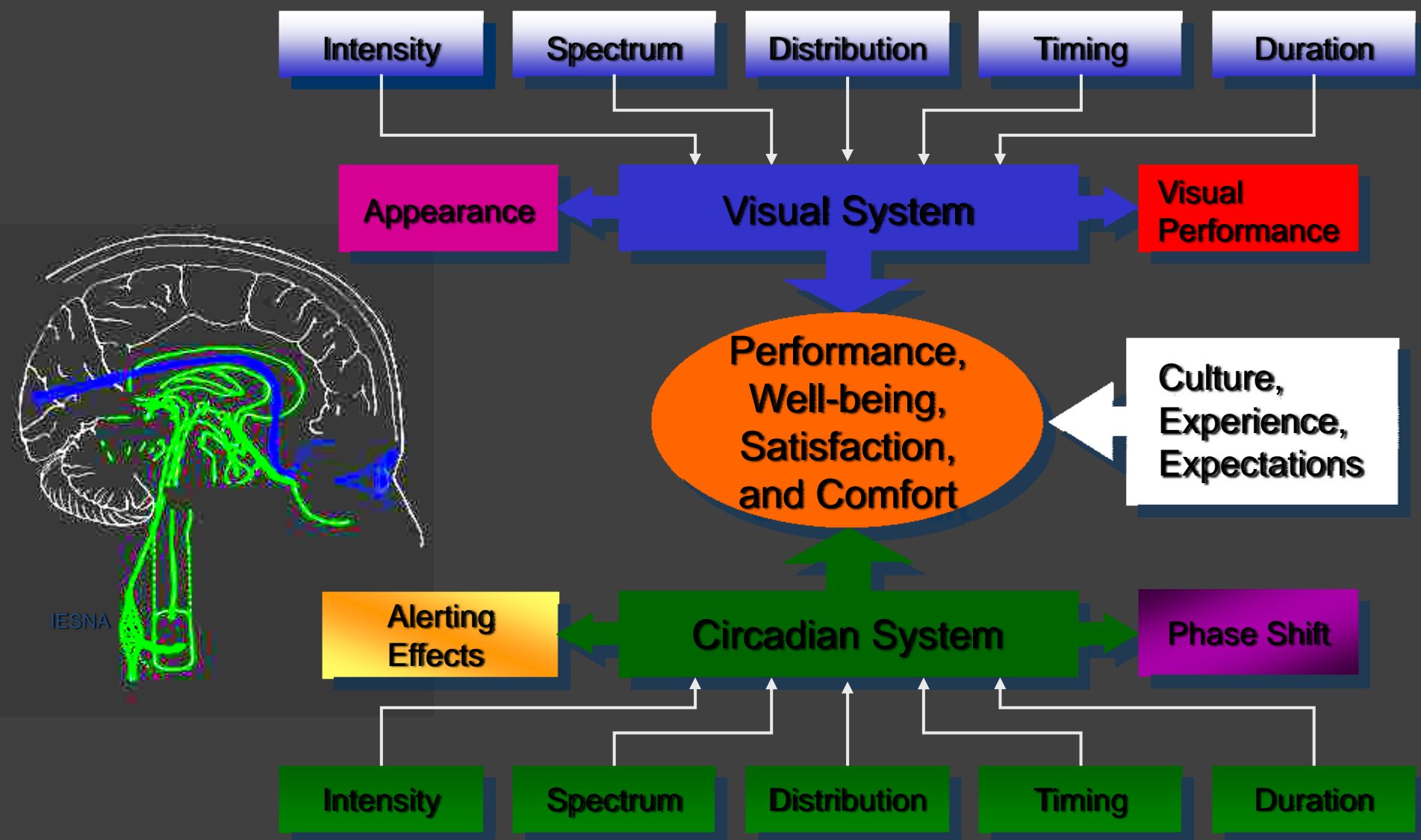
- Measurement

- Theory

- Application

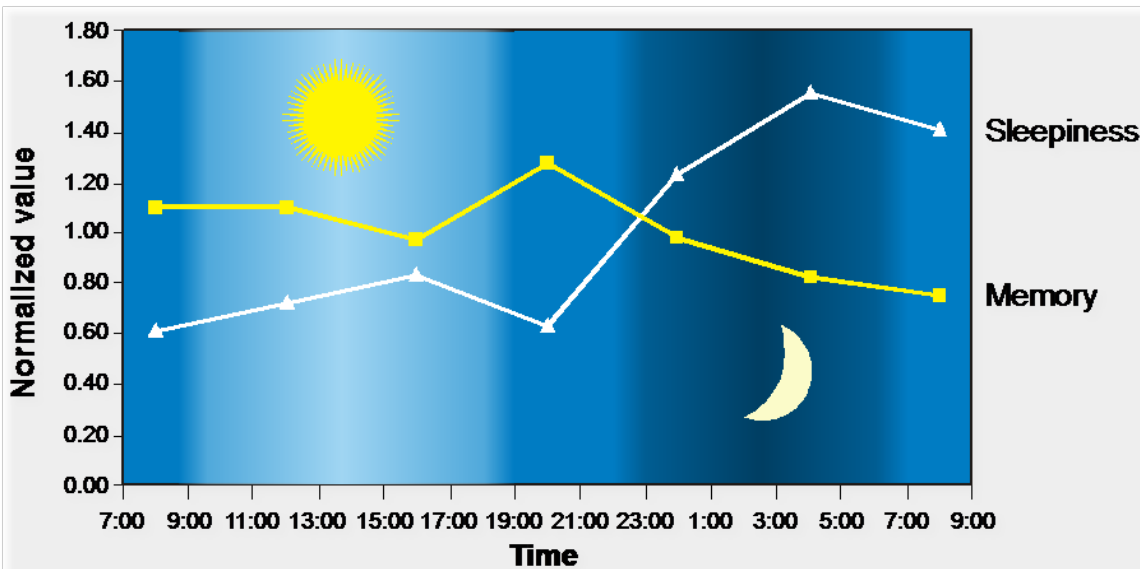


New paradigm for light



Light System for Personal Health

- Direct effect of light on circadian rhythm through non-visual receptors
- Disruption of circadian linked to major health problems
- Personal Light System:
 - Circadian rhythm estimator based on entrainment model and daysimeter data
 - Optimized lighting control with daysimeter feedback for entrainment



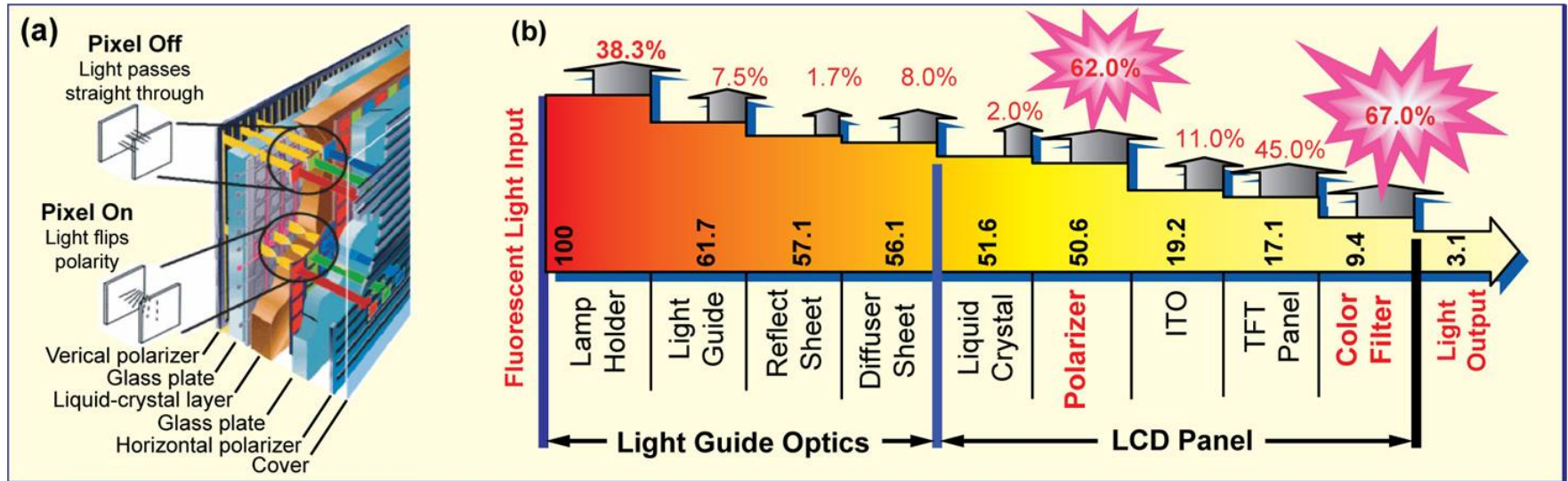
Light sensors

Activity monitor

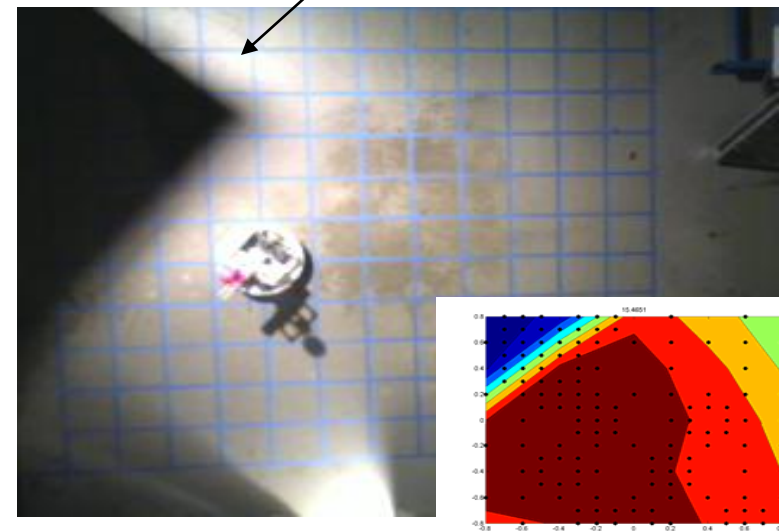
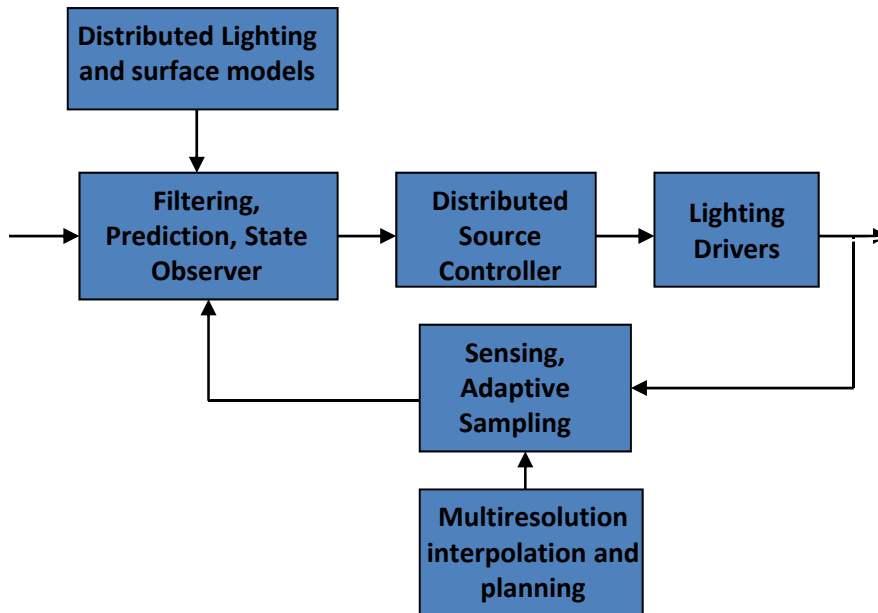
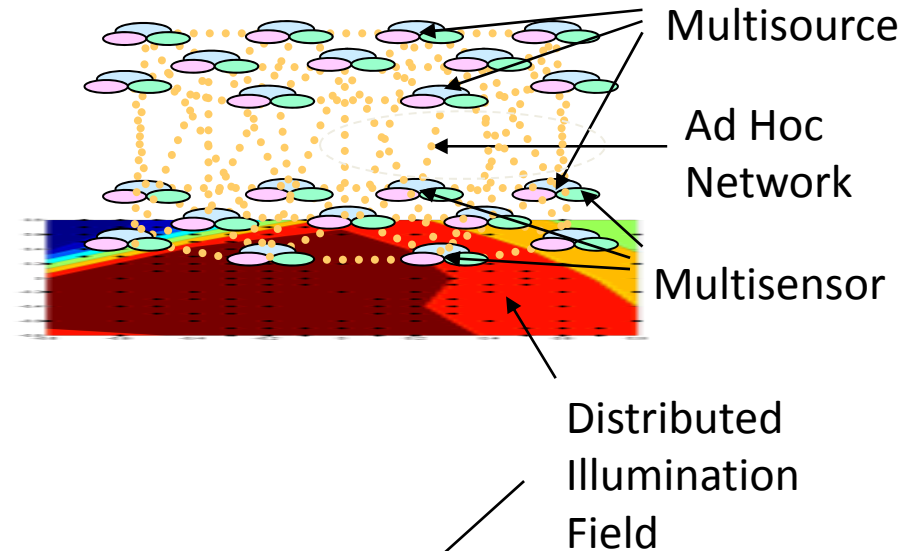
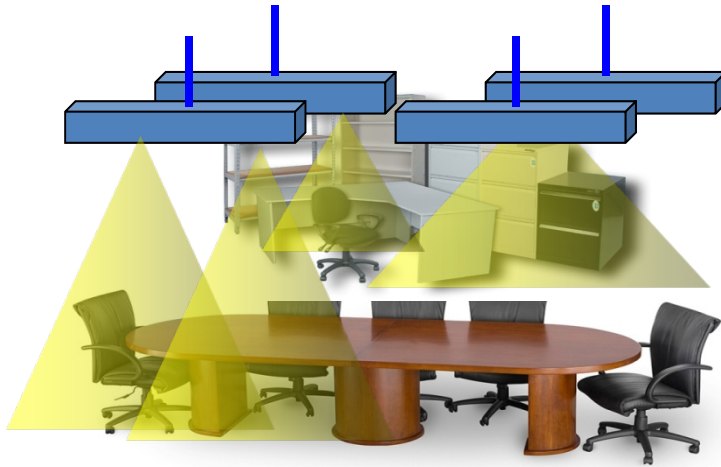


Energy Efficient Displays

- Polarized LEDs will provide huge energy savings!



Distributed Adaptive Lighting and Display

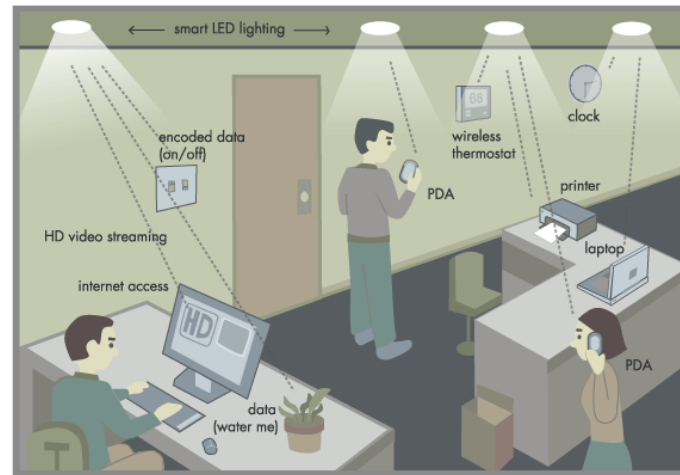


Visible Light Communications (Dual-Use)

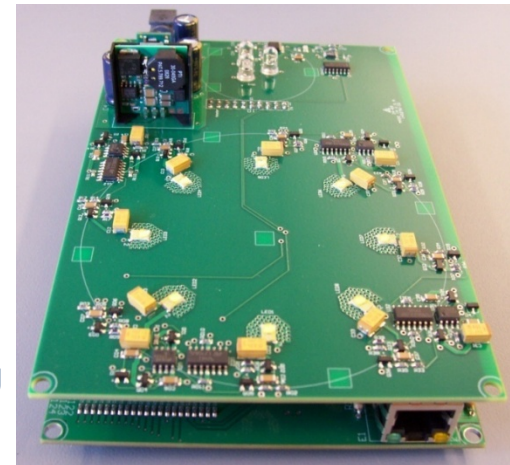
High Bandwidth Density



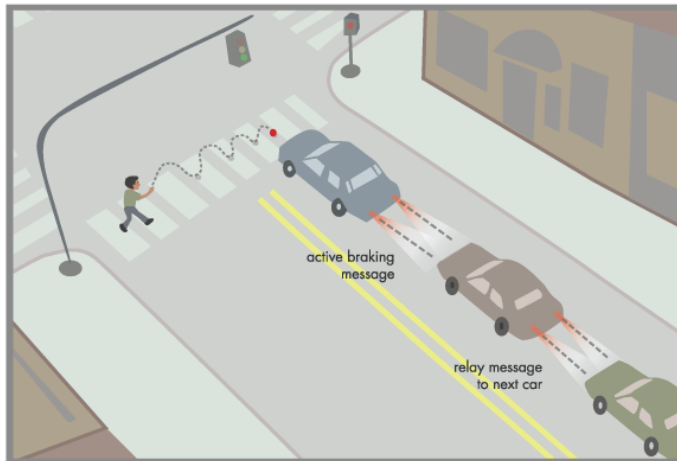
Integrated Mobility



Prototype Module



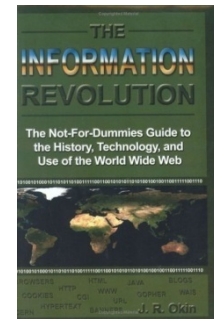
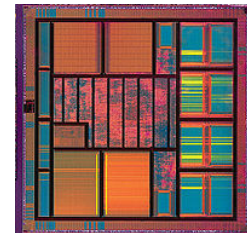
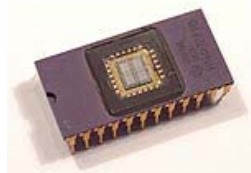
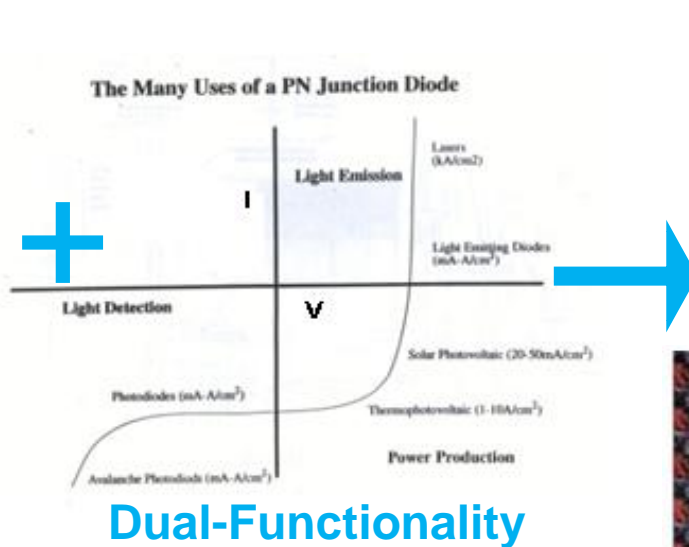
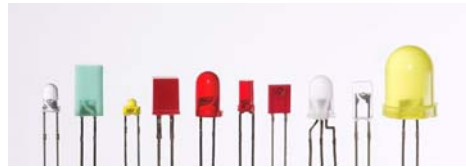
Critical Infrastructure Applications



Tom Little, BU

Digital Light Sources: Vision

- LEDs with Theoretical Performance Limits
- Fabrication & Processing Technologies for Nano-scale and Large Area LEDs
- “Smart-Adaptable LEDs”: Multi-functional, Integrated Electronic-Photonic Device & Circuit Architectures



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Vision and Mission

Vision:

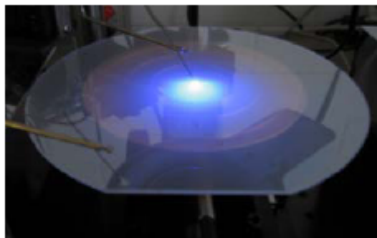
Ubiquitous, intelligent, and cost-effective lighting systems that will have a positive transformative impact on society

Mission:

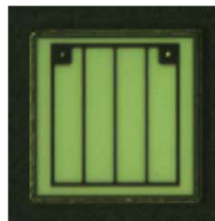
- Engage in research leading to smart lighting systems with adaptive and controllable properties not possible with incandescent and fluorescent lights
- Develop a culture of innovation and engage industry to help shape the center's research and commercialize its results
- Educate a diverse world-class workforce that will be needed to grow the business of Smart Lighting

SSL Value Chain & Other Players

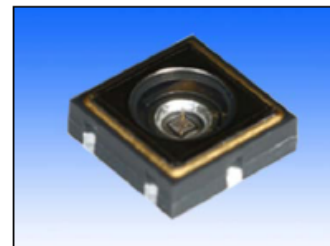
**Materials
Processes
Devices**



**Materials &
Subsystems**



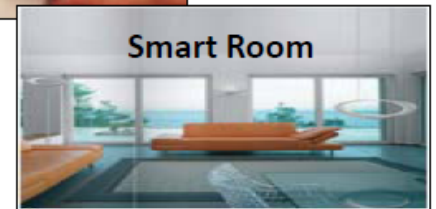
**Materials &
Subsystems
Integration**



**Full Systems
Integration**



Smart Room



Equipment Manufacturers

Standards/Regulations/Government

Economic Development Agencies/Market Analysis