The following are a selection

of the core slides from a DOE presentation

on 1/29/20. Some slides have been modified

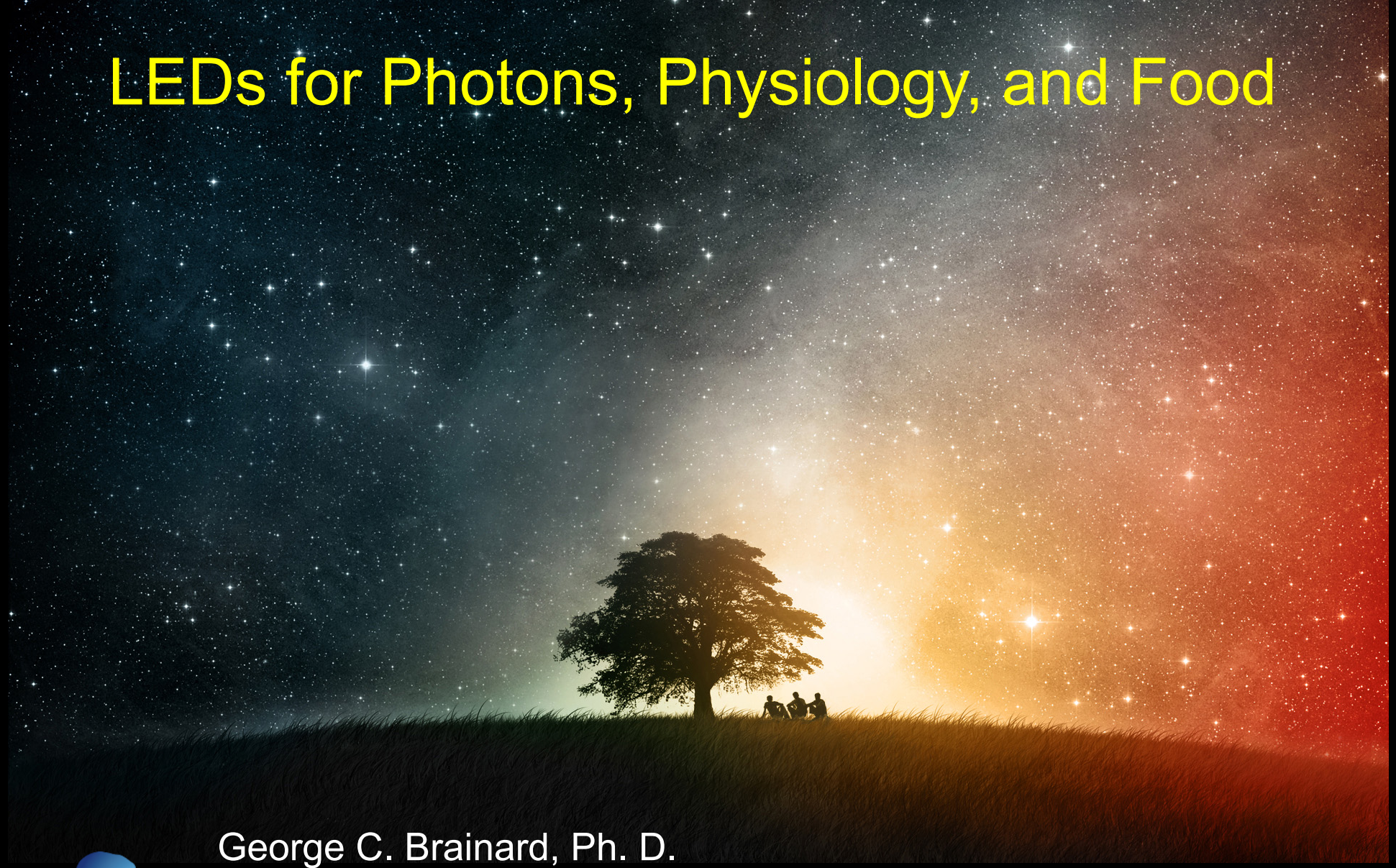
or deleted if the slide contained

unpublished data or the presenter did

not have copyright permission to distribute

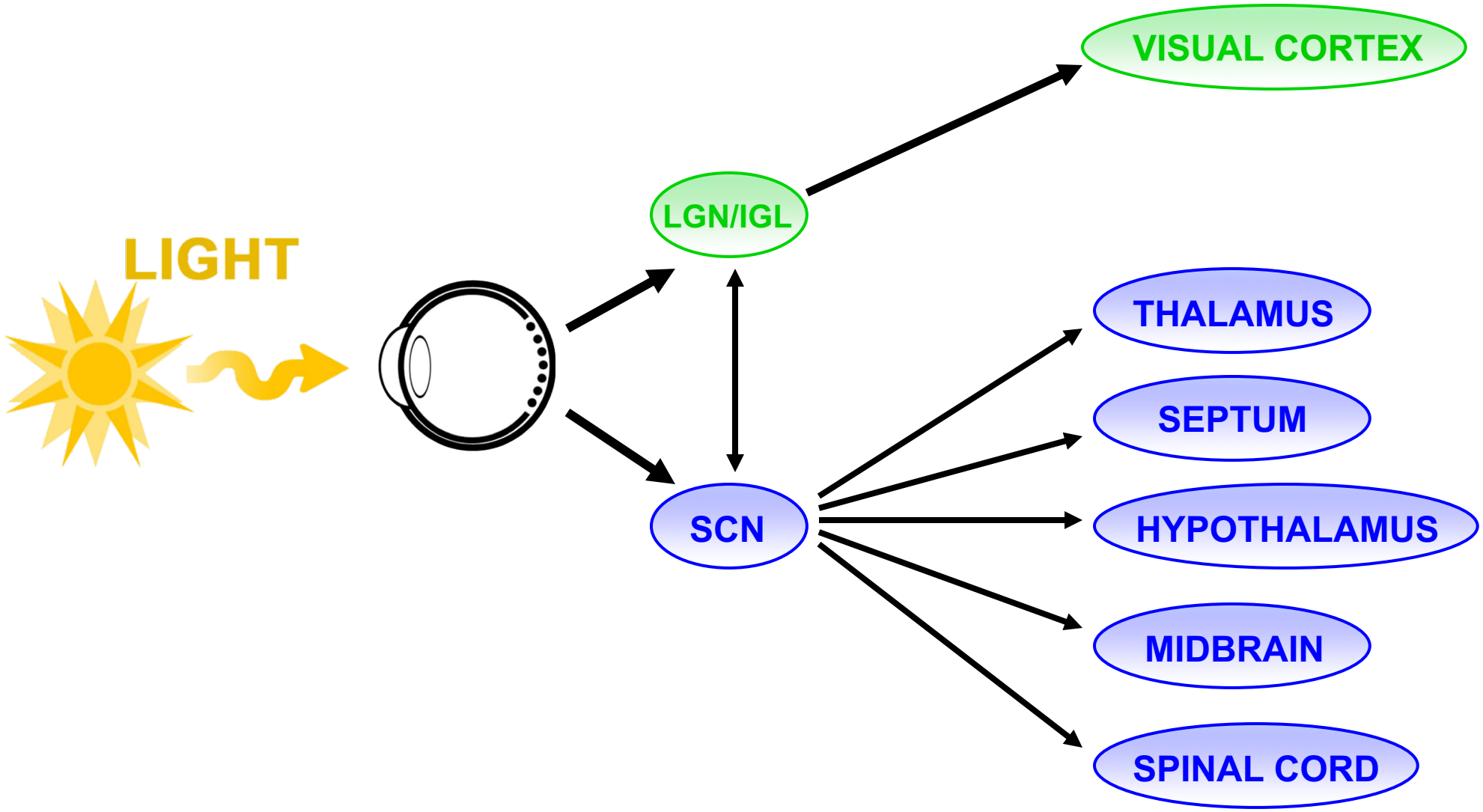
the images.

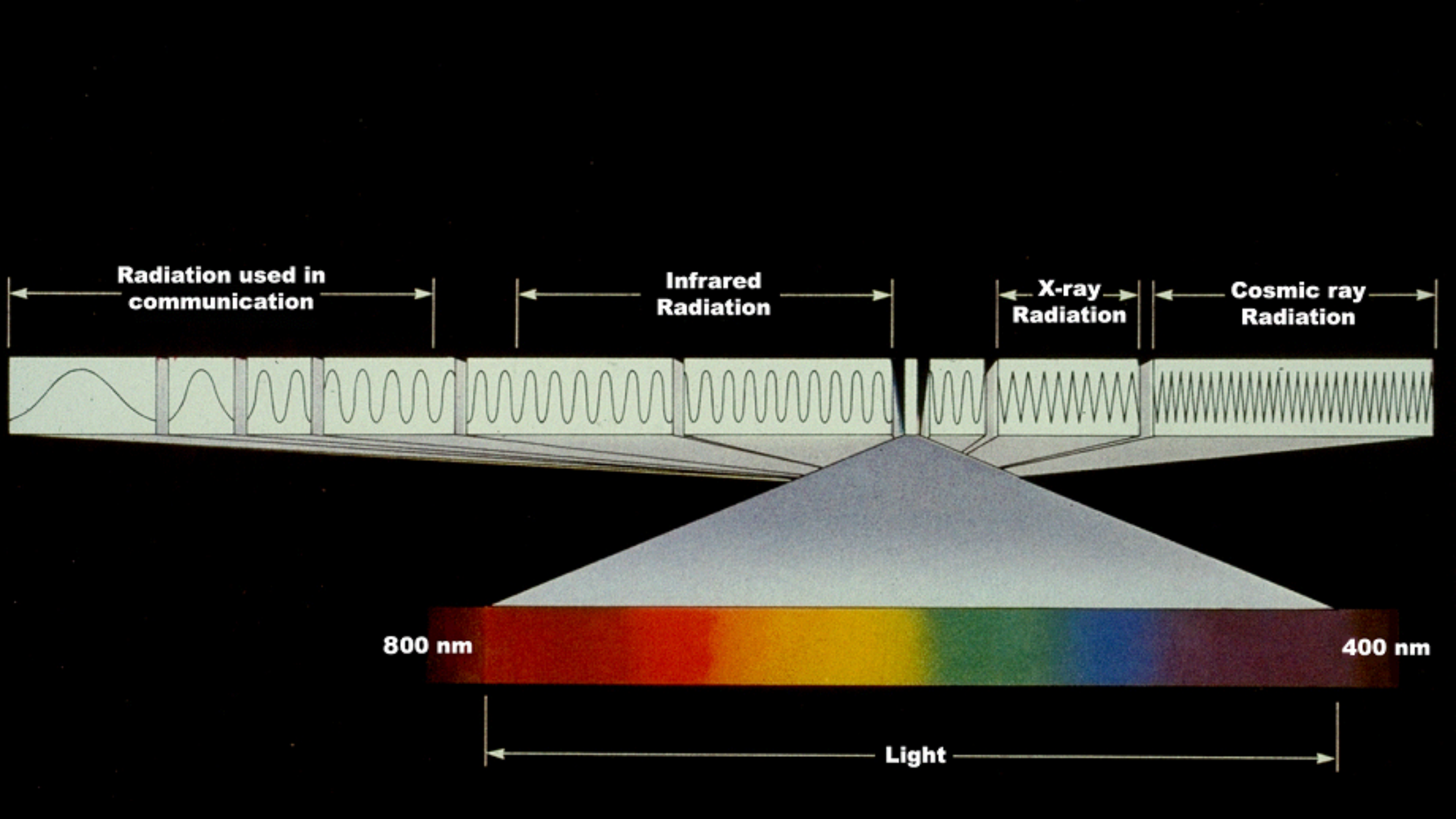
LEDs for Photons, Physiology, and Food



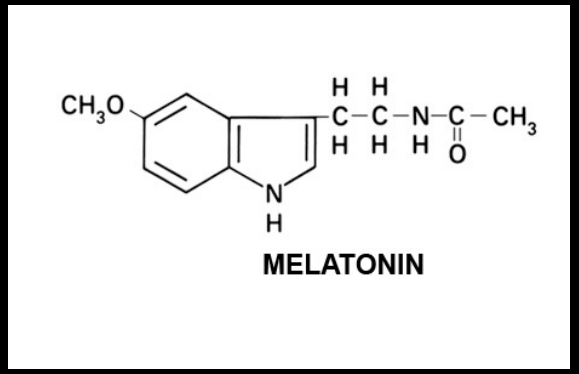
George C. Brainard, Ph. D.

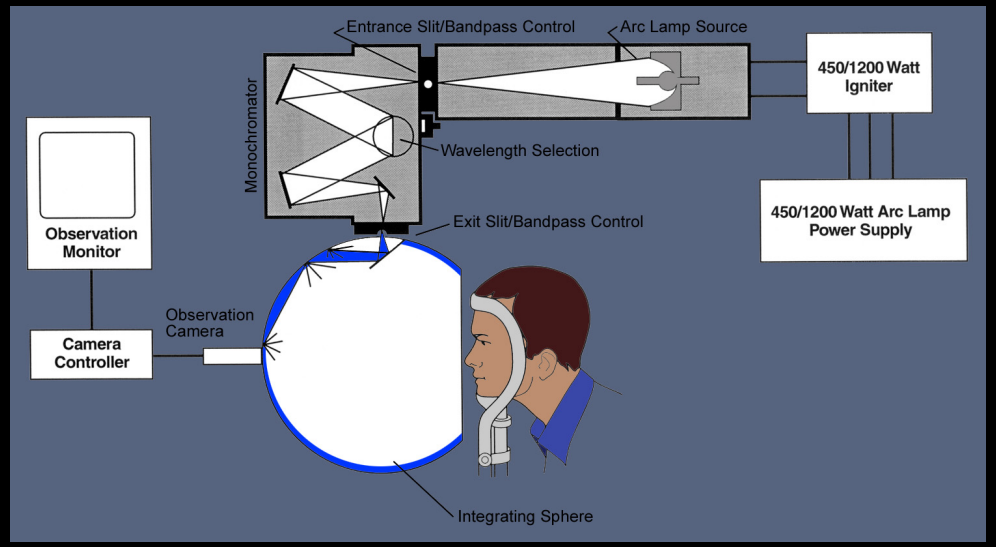
Professor of Neurology
Thomas Jefferson University
Philadelphia, Pennsylvania

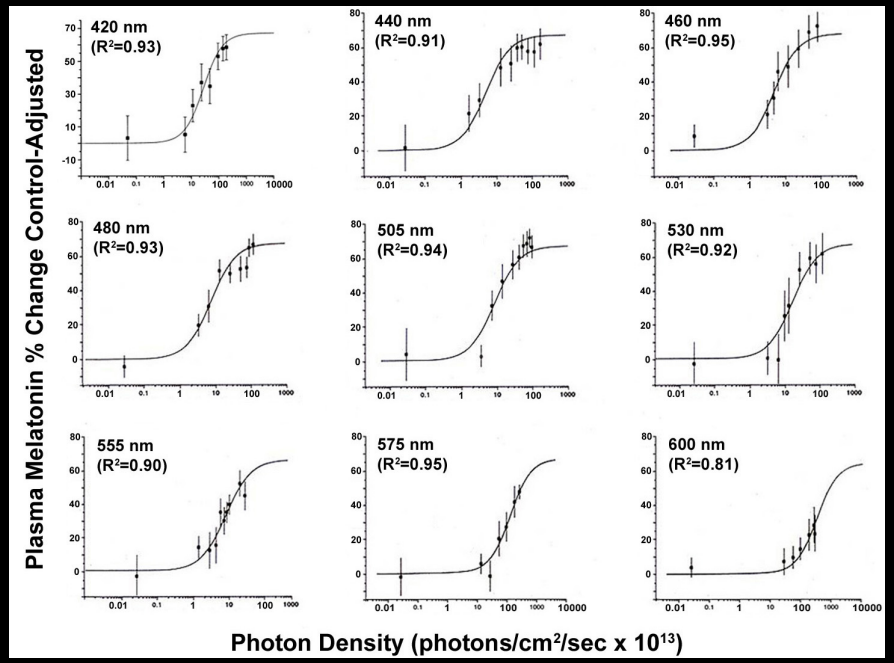

LIGHT
LGN/IGL
VISUAL CORTEX
SCN
THALAMUS
SEPTUM
HYPOTHALAMUS
MIDBRAIN
SPINAL CORD

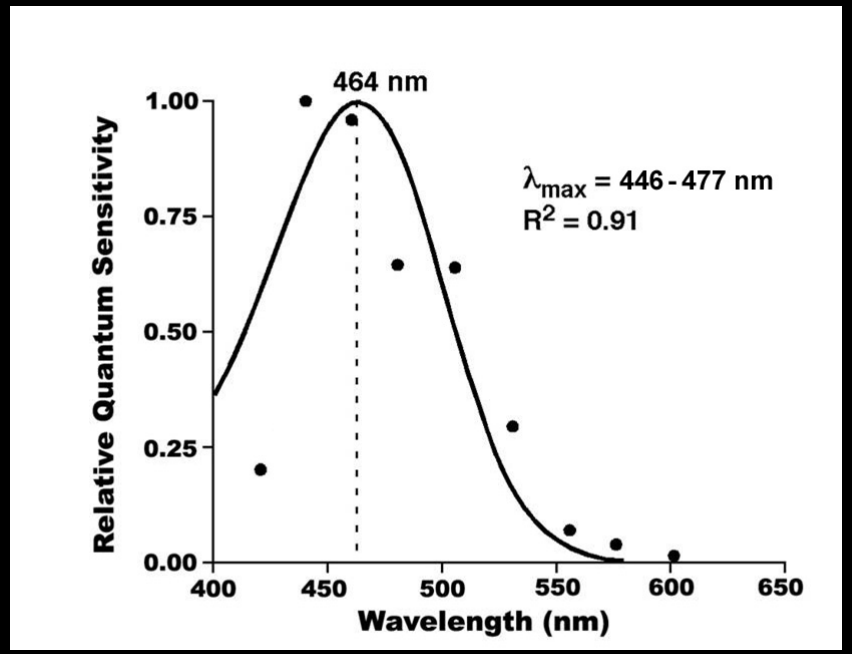

Radiation used in communication
Infrared Radiation
X-ray Radiation
Cosmic ray Radiation
800 nm
400 nm
Light

Melatonin Action Spectrum





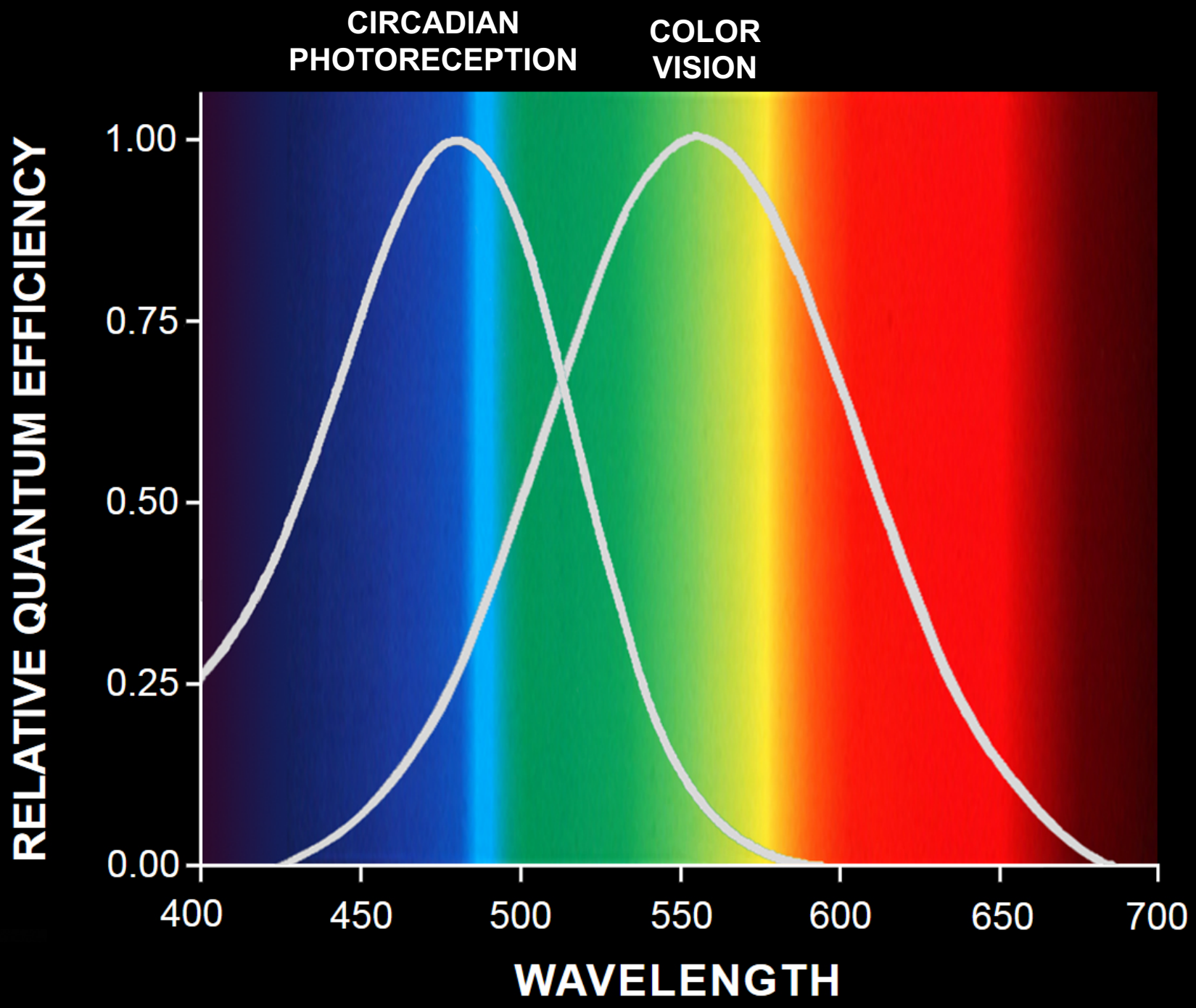




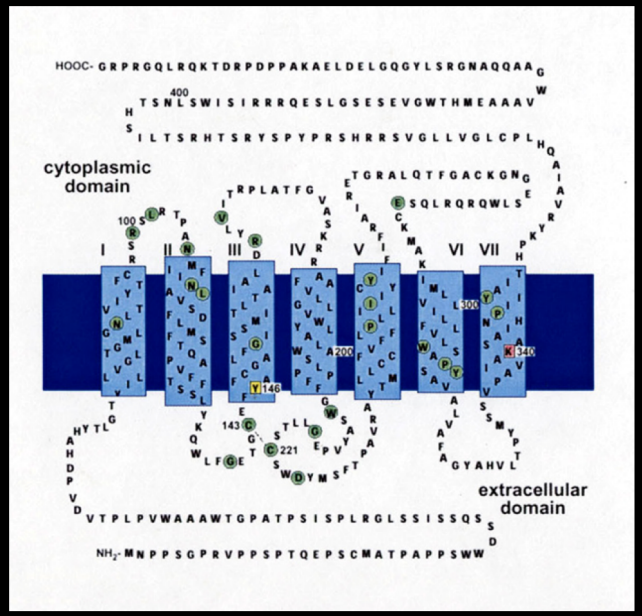
Brainard et al. J. Neuroscience, 2001; J. Biol. Rhythms, 2008

SHORT WAVELENGTH ACTION SPECTRA

λ Max	Species	Response	Author, Year
480	Mouse *rd/rd*	Circadian Phase-Shifting	Yoshimura 1996
464	Human	Melatonin Suppression	Brainard 2001
459	Human	Melatonin Suppression	Thapan 2001
479	Mouse *rd/rd*	Pupillary Light Reflexes	Lucas 2001
483	Human	Cone Cell ERG–wave	Hankins 2002
484	Rat	Ganglion Cell Depolarization	Berson 2002
481	Mouse *rd/rd cl*	Circadian Phase-Shifting	Hattar 2003
482	Monkey	Ganglion Cell Depolarization	Dacey 2005
482	Monkey/Human	Pupillary Light Reflex	Gamlin 2007
480	Human	Pupillary Light Reflex	Zaidi 2007
479	Human (*in vitro*)	Melanopsin Ca^{2+} Reponse	Bailes 2013


CIRCADIAN PHOTORECEPTION
COLOR VISION
RELATIVE QUANTUM EFFICIENCY
1.00
0.75
0.50
0.25
0.00
400
450
500
550
600
650
700
WAVELENGTH

Human Melanopsin
Provencio et al. *J. Neurosci.* 2000



Gooley et al. *Nature Neurosci.* 2001

Berson et al. *Science* 2002

Hattar et al. *Science* 2002

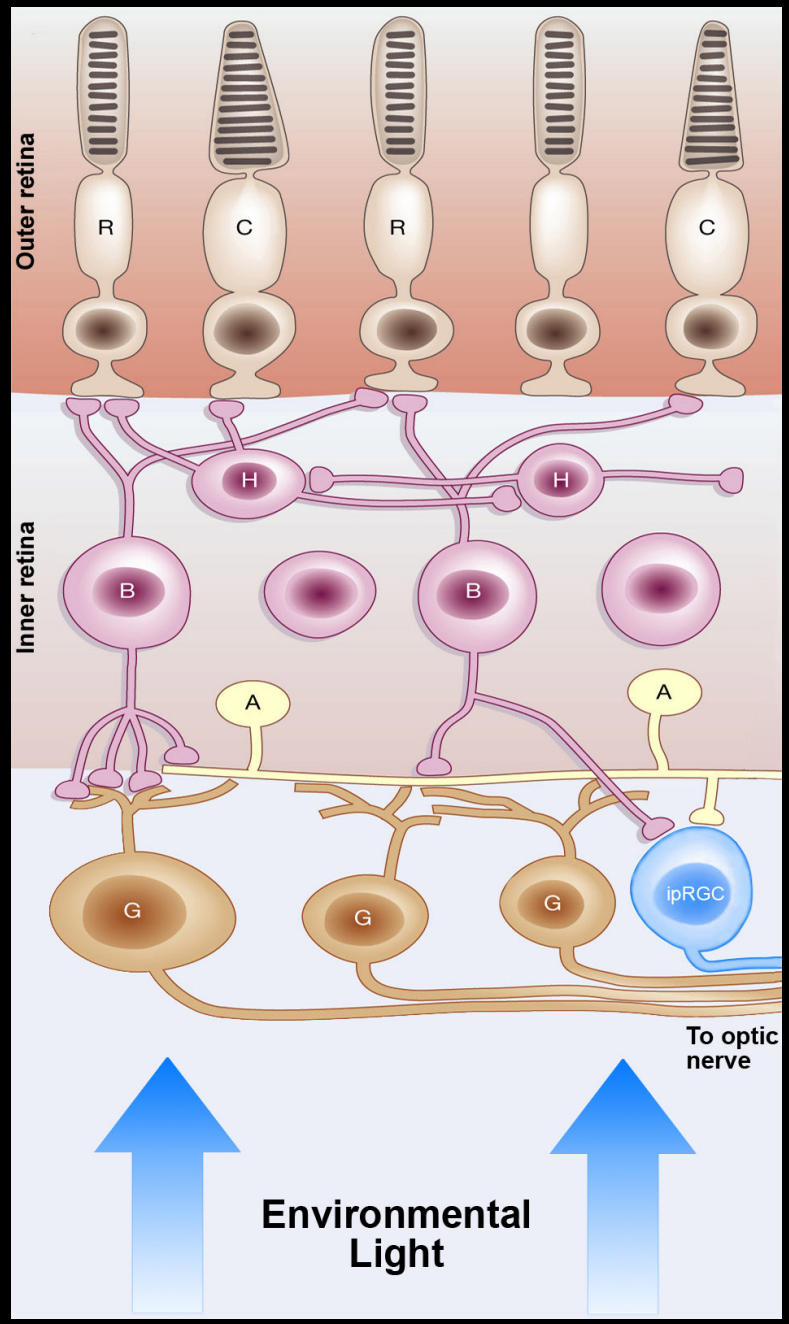
Provencio et al. *Nature* 2002

Hattar et al. *Science* 2003

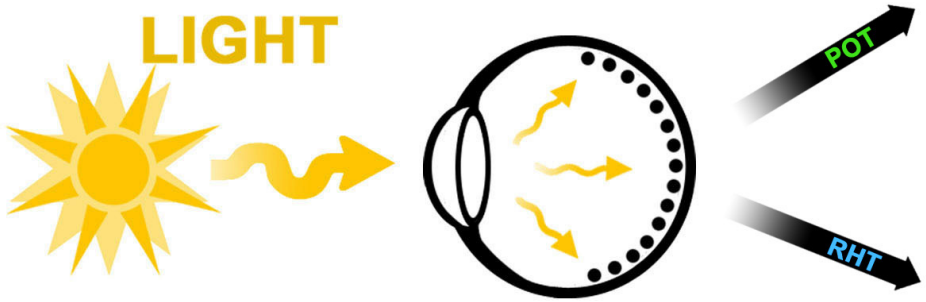
Altimus et al. *Nature Neurosci.* 2010

Lall et al. *Neuron* 2010

Hannibal et al., J. Comp. Neuro. 2017



Adapted from Foster *Nature* 2005

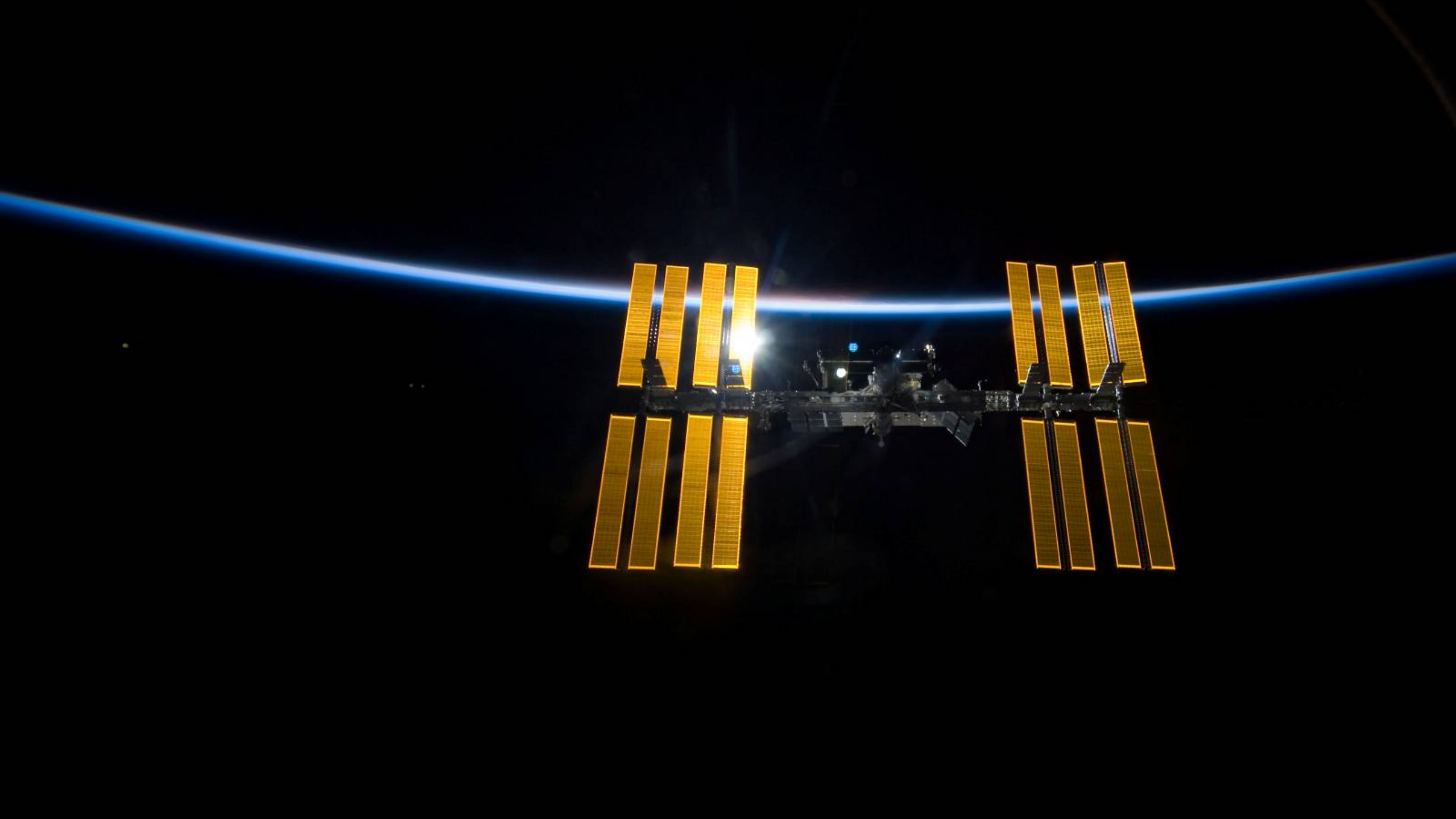


VISUAL EFFECTS
VISUAL REFLEXES

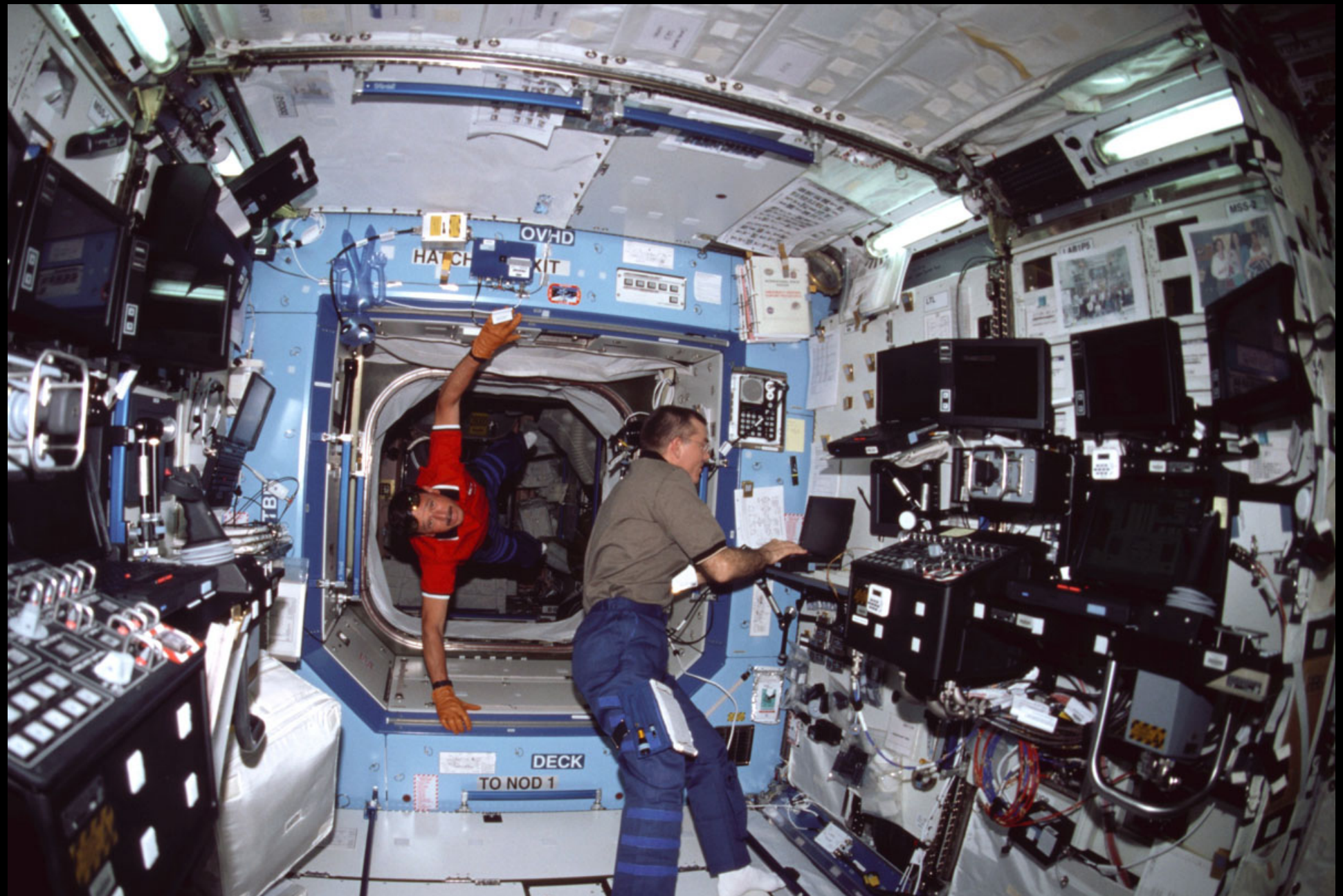
BIOLOGICAL/BEHAVIORAL

Acute Effects
- Melatonin Secretion
- Body Temperature
- Cortisol Secretion
- Heartrate
- Alertness
- Brain Bloodflow
- EEG Responses
- Clock Gene Expression
- Cognitive Performance
- Psychomotor Performance

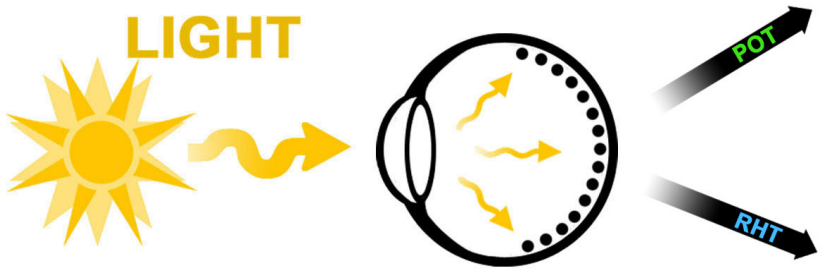
Longer Term Effects
- Circadian Phase-Shift
- Circadian Entrainment
- Sleep Physiology
- Light Therapy (eg SAD)



ISS Destiny Module 2001



Solid State Lighting Assembly (SSLA) for the ISS

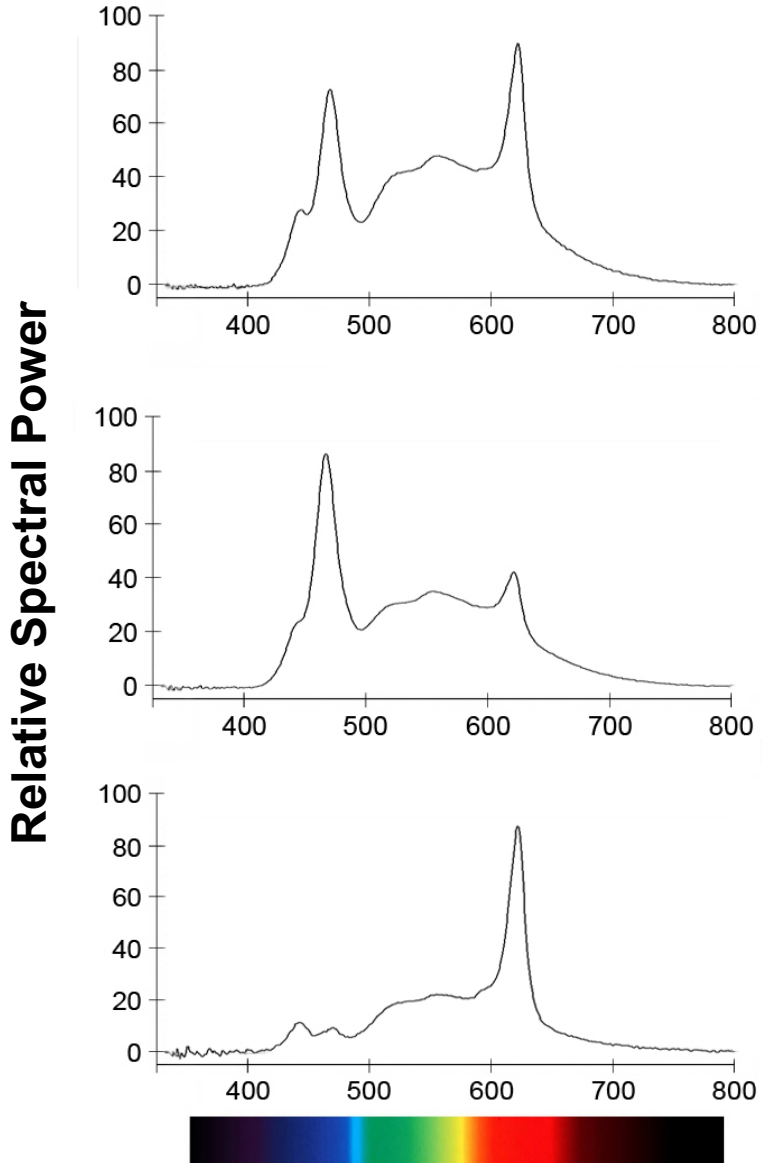


VISUAL EFFECTS
VISUAL REFLEXES

BIOLOGICAL REGULATION
BEHAVIORAL EFFECTS

- Developed: Kennedy Space Center, Bionetics, Lighting Sciences Group
- Multi-institutional ISS flight study in process (JSC/TJU/Harvard)

NASA Specifications of SSLA Lighting for ISS



General Vision
238 lux

Alerting / Phase Shift
1070 lux

Pre-Sleep
20 lux

Crew Sleeping Quarters (CQ)

CQ Node 2:
ISS

Precise CQ replica
TJU Philadelphia

Unpublished
Numerical Verification Test data
with 4800 K light was provided here

Light For Vision

Unpublished
Melatonin Suppression data
With 4800 K was provided here

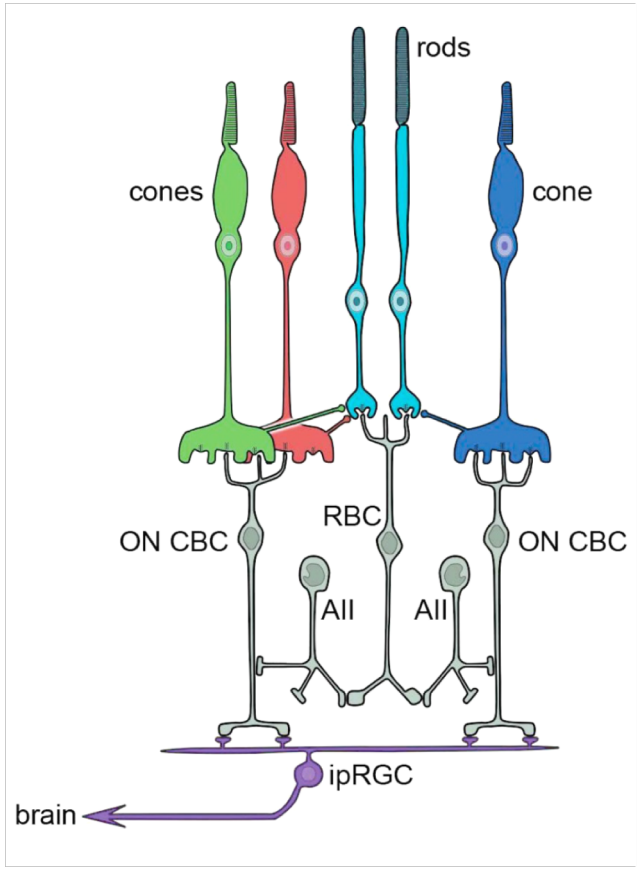
Light For Biology

ISS Lighting Countermeasure for Sleep and Circadian Disruption

Kate Rubins, Ph.D.

- First SSLA installed in 2016 in Dr. Rubins' Crew Sleeping Quarters
- Sixty five solid state modules installed on ISS (January 2020)

Hand-held Photometer/Radiometer Onboard ISS



Lucas et al., Trends in Neurosciences 37(1): 1-9 (2014)

↓

CIE Reportership: CIE TN 003 (2015)

↓

CIE DS 026 Standard: (2018)

Two Slides:
Unpublished Spectral Data from ISS mission

Ground Studies and ISS Flight Study Measures

Circadian entrainment

Melatonin

Sleep duration

Sleep quality

Sleep onset

Color vision

Visual performance

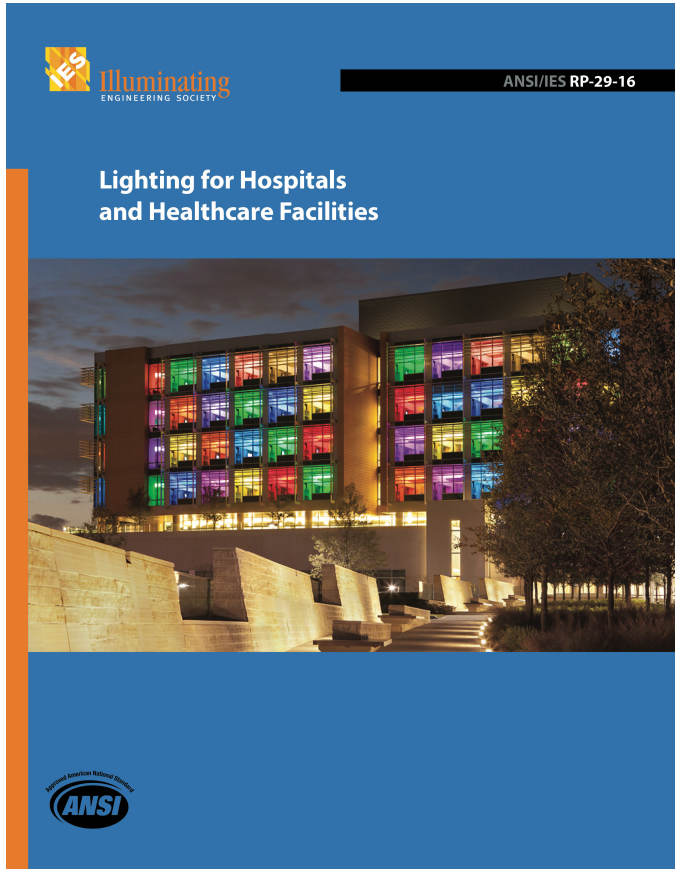
Subjective alertness

Objective alertness

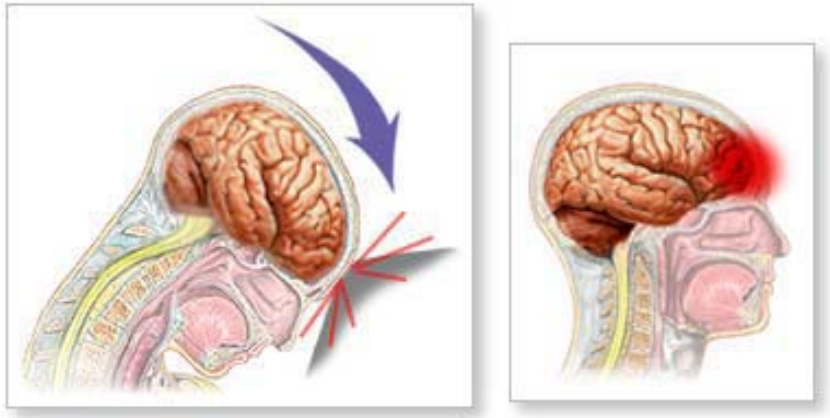
Neurocognitive responses

From Spacecraft Lighting to the Patient Bedside

LESA
Lighting Enabled Systems & Applications



Circadian, Sleep and Mood Disturbance in Brain Injury



Concussion
(mTBI)

Ischemic
Stroke

Hemorrhagic
Stroke

Preliminary Sleep/Wake Actigraphy Data: Ambulatory Stroke Patients

Unpublished

Sleep Onset data in stroke patients and control subjects was provided here

Built-in Hospital Lighting for Inpatients With Brain Injuries

- Located in a neurointensive ICU at the Jefferson Hospital for Neurosciences
- Variable SPD lighting from Telelumen in an operational medical setting
- Real-time, closed-loop control capable system
- Compatible with biometric feedback and ceiling based actigraphy