

Light, Health and Wellbeing: Implications from Chronobiology for Architectural Design

InnoBYG Conference 15.5.2014

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Light in its third dimension

The biological aspect of lighting design for better quality of life

SEE THE WORLD IN A NEW LIGHT **OSRAM** 

BI BRANDI INSTITUTE
FOR LIGHT
AND DESIGN

UPCOMING COURSES IN 2013 / 2014

Health-Wellness-Light: 4.-8.Nov.2013
Biological Lighting: February 2014

Light has a triple effect

- Light for **visual** functions
 - Illumination of task area in conformity with relevant standards
 - Glare-free and convenient
- Light creating **biological** effects
 - Supporting people's circadian rhythm
 - Stimulating or relaxing
- Light for **emotional** perception
 - Lighting enhancing architecture
 - Creating scenes and effects



NA 058-00-27 AA (FNL 27)
„Wirkung des Lichts auf den Menschen“

DIN Deutsches Institut für Normung e. V.

DIN

Biologisch wirksame Beleuchtung - Planungsempfehlungen

Vorstellung der DIN SPEC 67600:2013-04

**Matthias
Fassian**
Philips GmbH

**Andreas
Wojtysiak**
OSRAM GmbH

**Wolfgang
Scharpenberg**
INLIGHT GmbH

**Ulf
Greiner Mai**
Beratender Ingenieur VBI



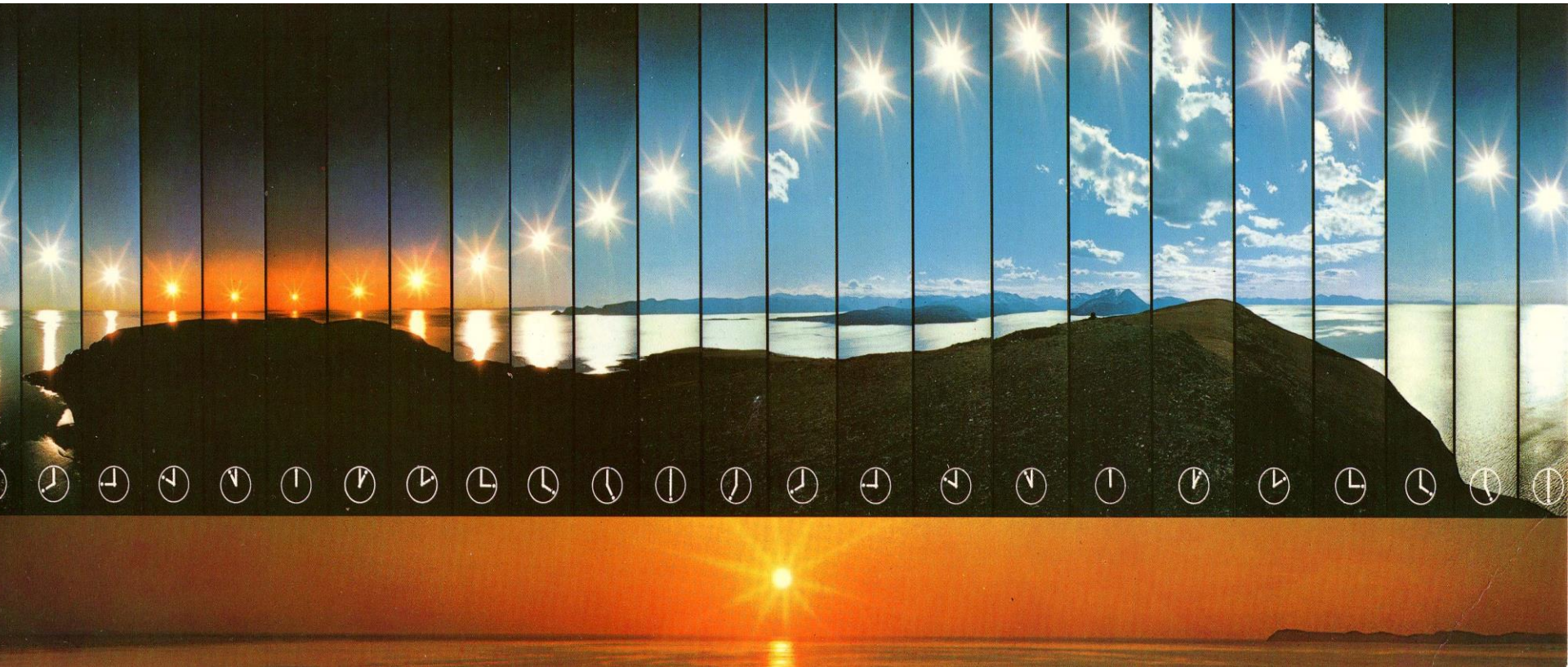
Visual Function



**Non-visual
Functions**

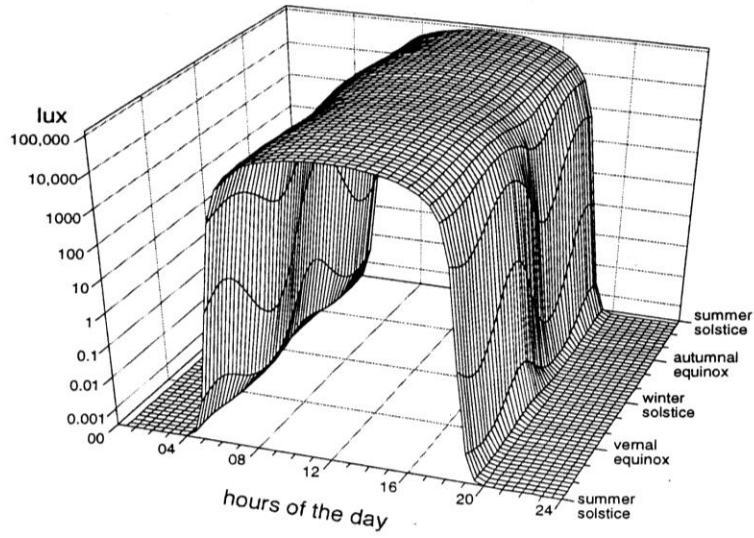
Light and the Brain

The Natural Environment

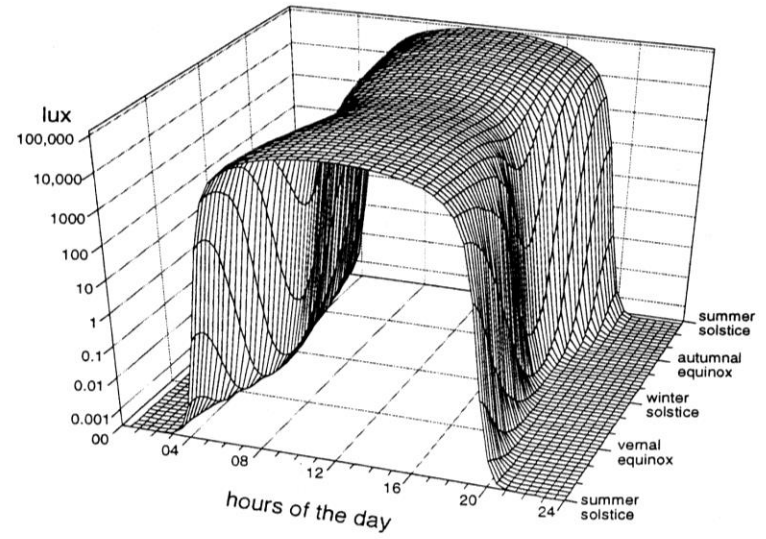


**Day-night cycle with dawn-dusk transitions
and seasonal changes in daylength**

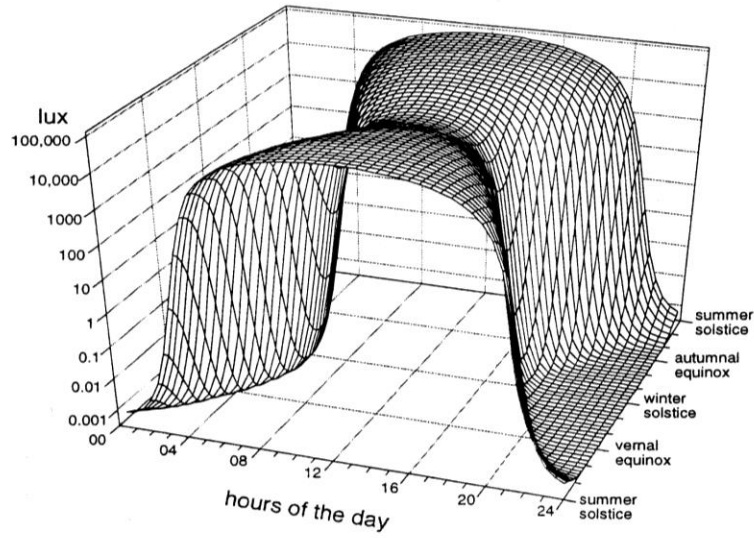
0° lat



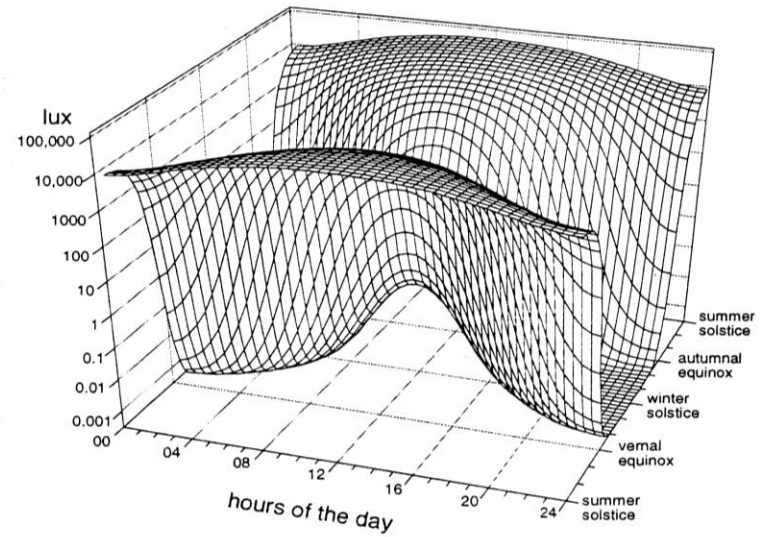
25° N lat



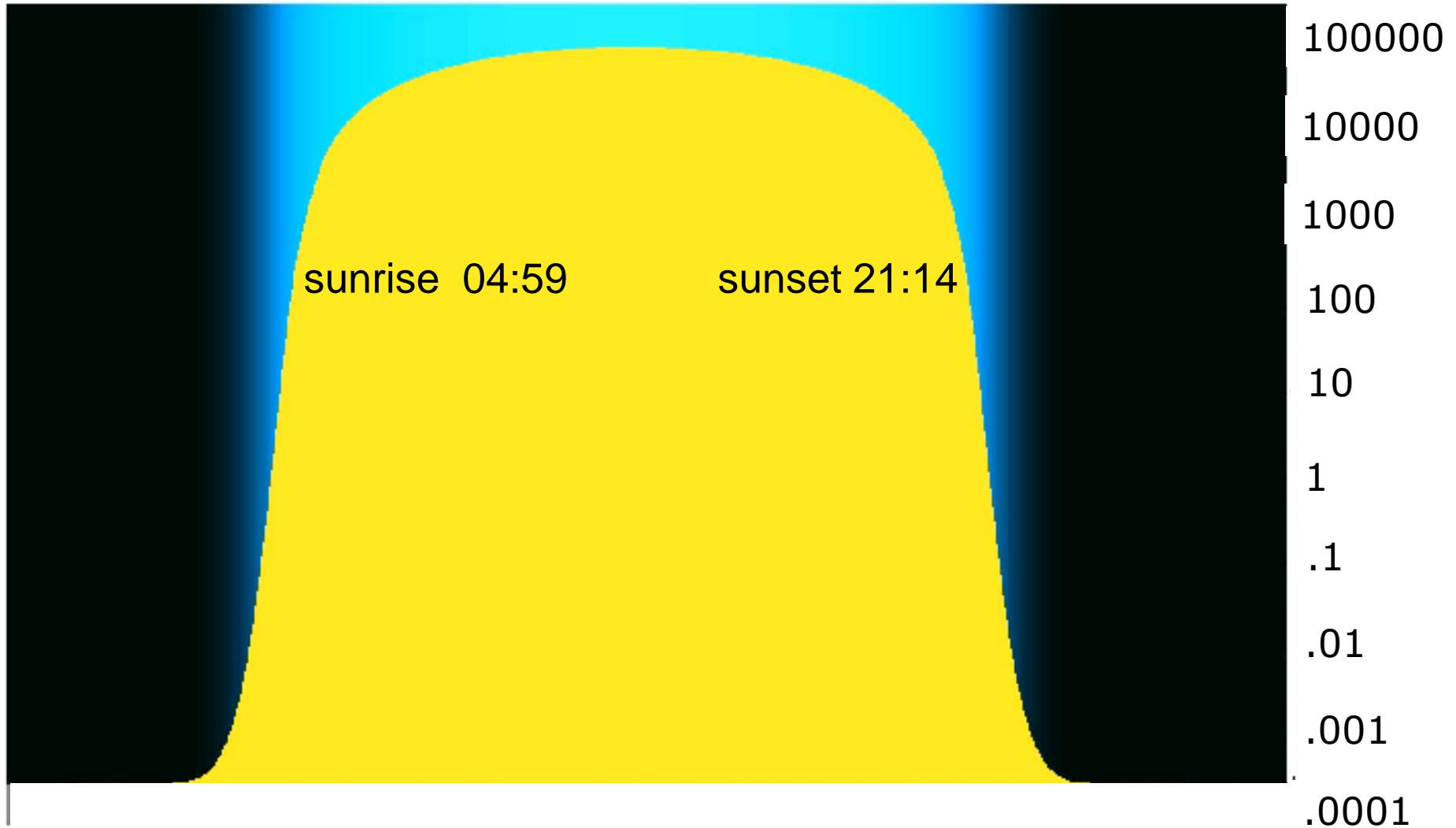
50° N lat



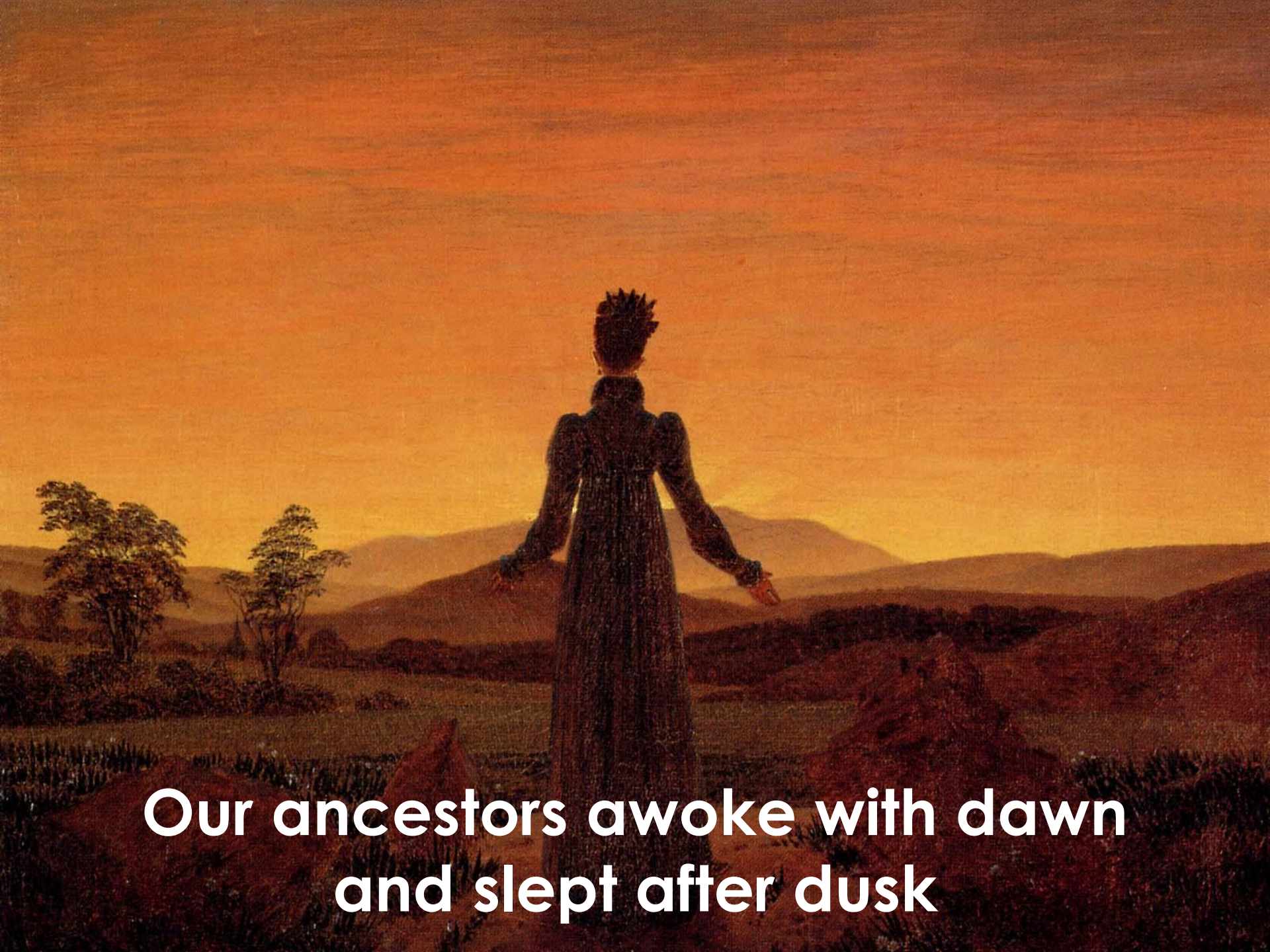
75° N lat



Daylight is dynamic

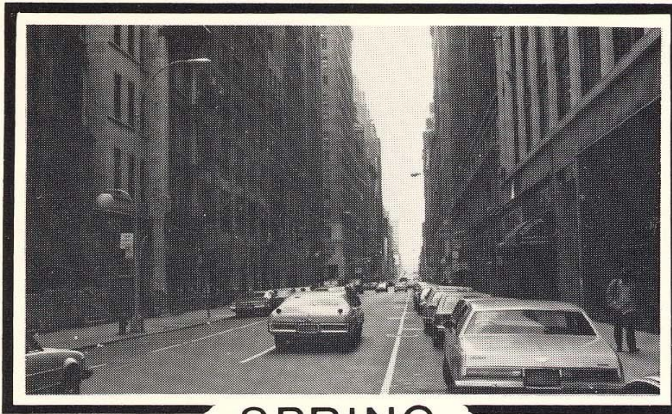


Copenhagen 55° 40' N, 12° 35' E 15 May 2014

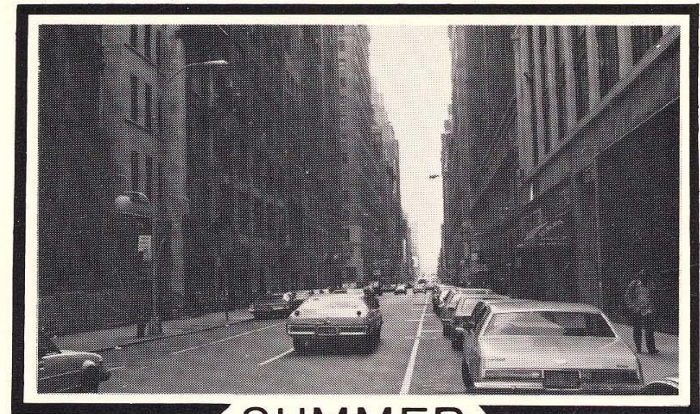


**Our ancestors awoke with dawn
and slept after dusk**

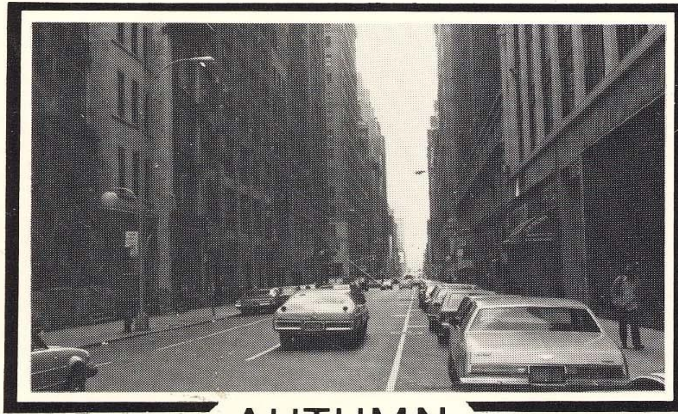
Humans are seasonal, but the seasons have diminished in impact



SPRING



SUMMER



AUTUMN

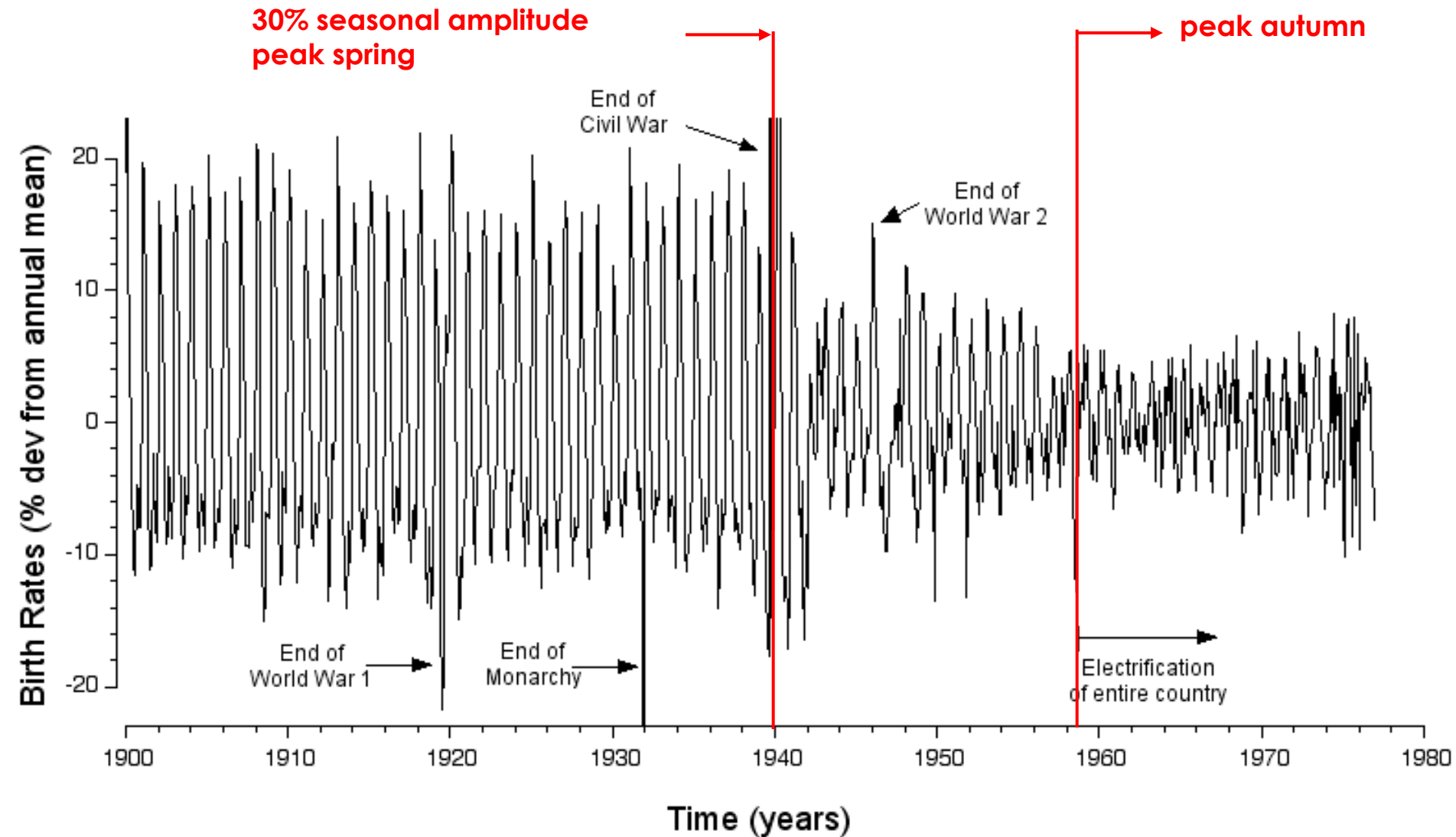


WINTER

is it the advent of artificial light and heating?

Seasonal and social influences on human reproduction

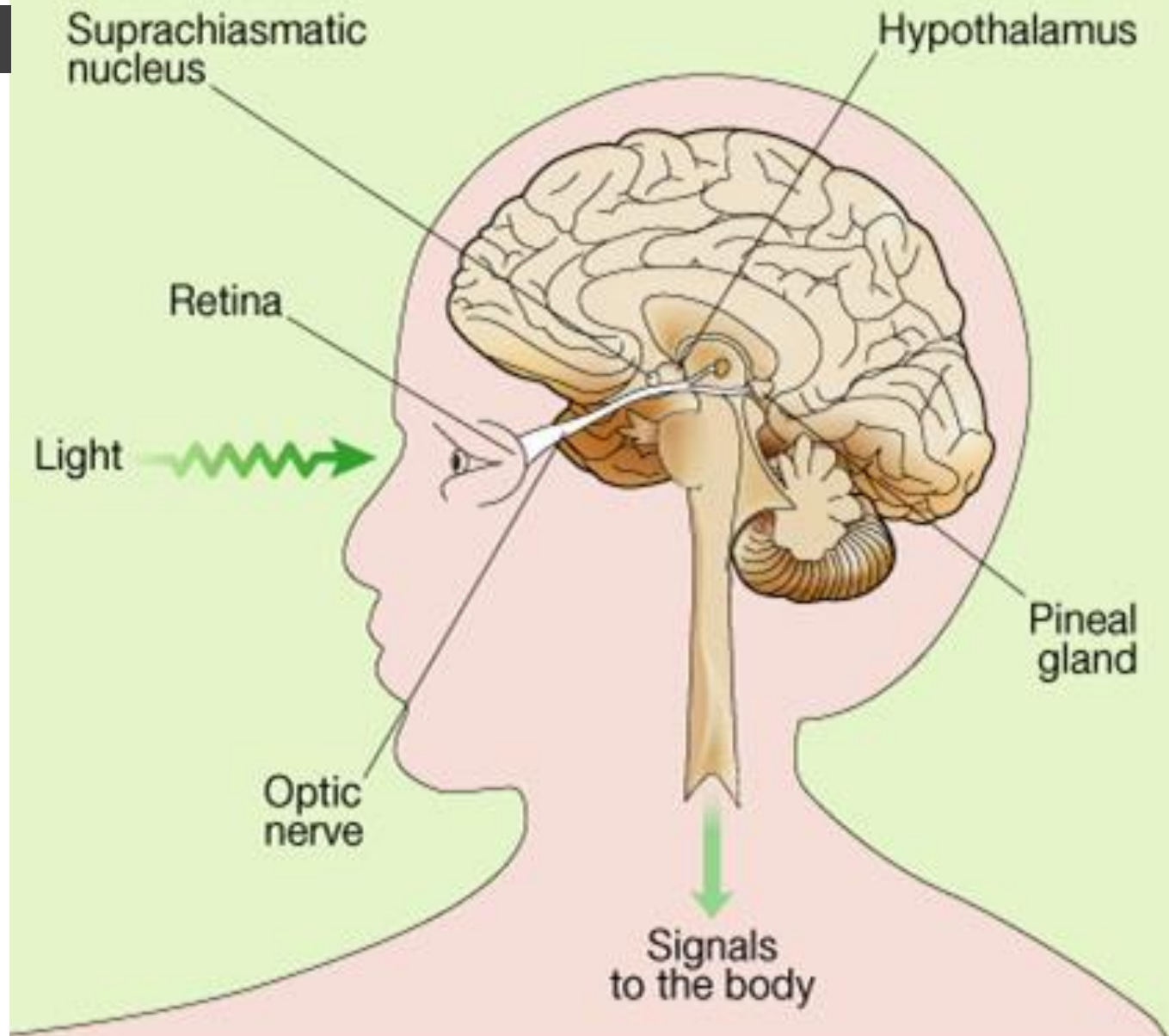
Monthly birth rates in Spain 1900- 1978



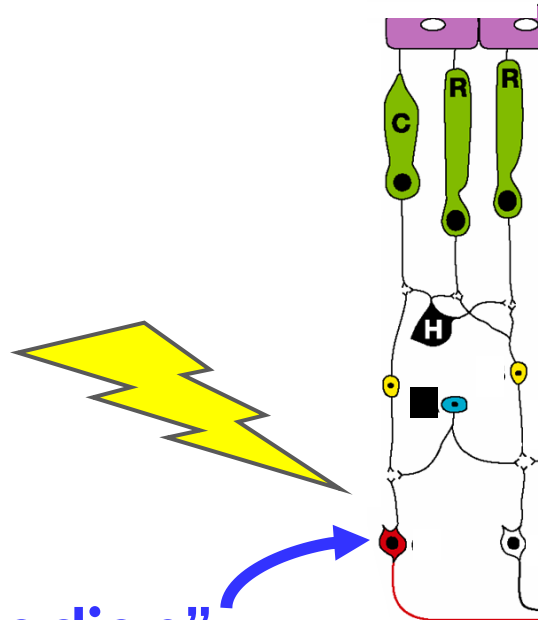
Non-visual function: light is a Zeitgeber

= Synchronising agent

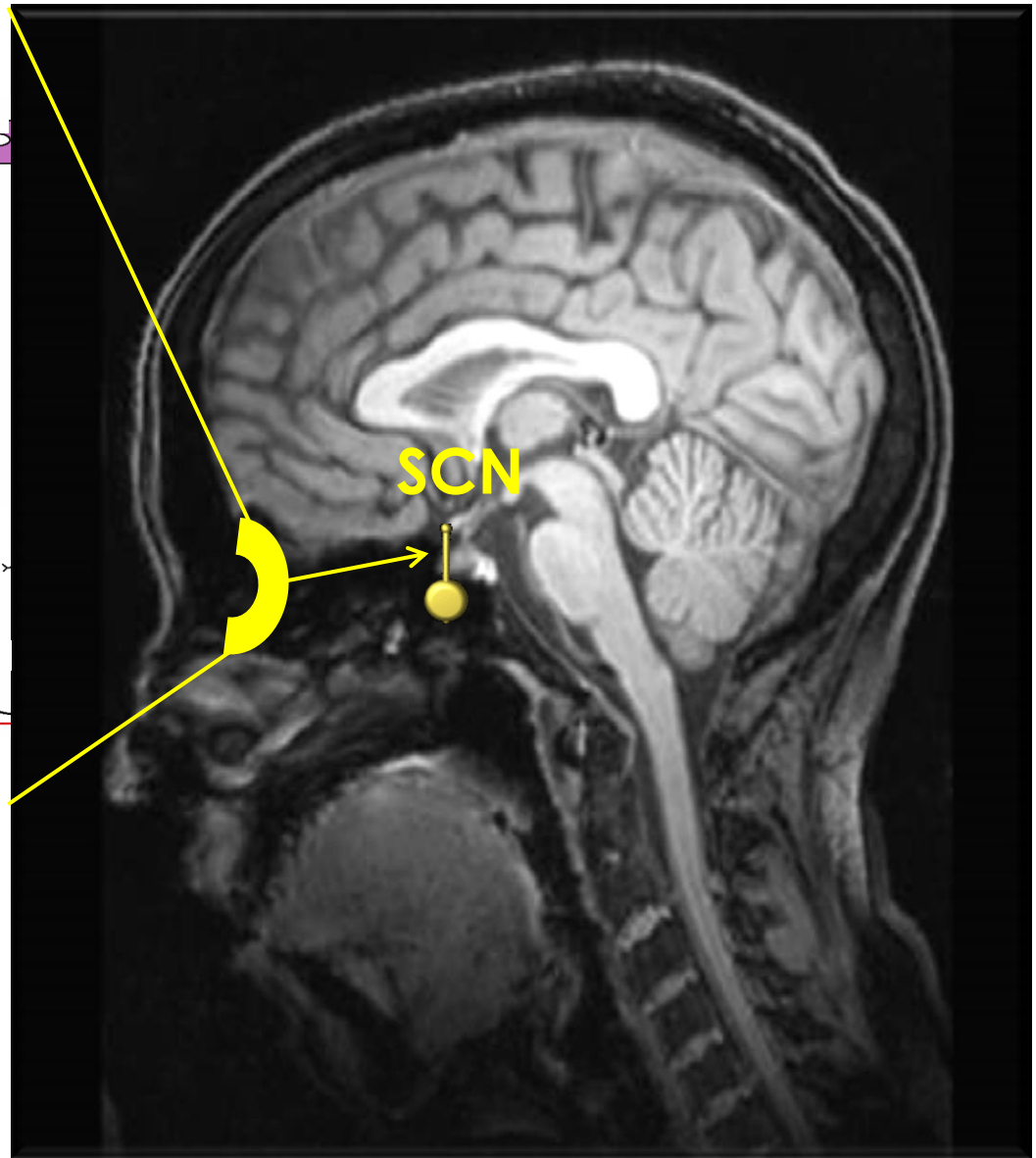
for the biological clock



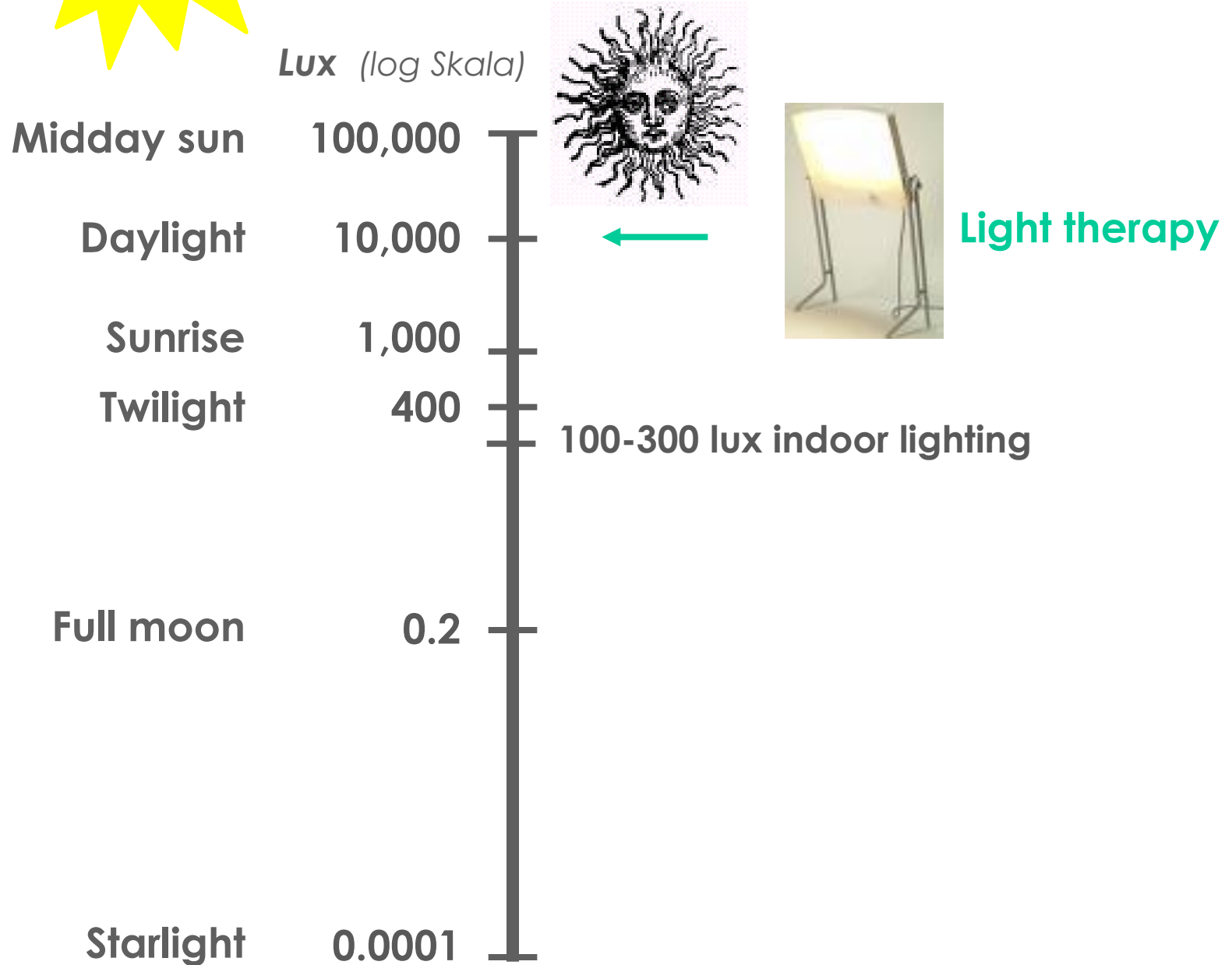
Spectral composition of light is relevant



“circadian”
photoreceptor with
blue-sensitive
photopigment
melanopsin

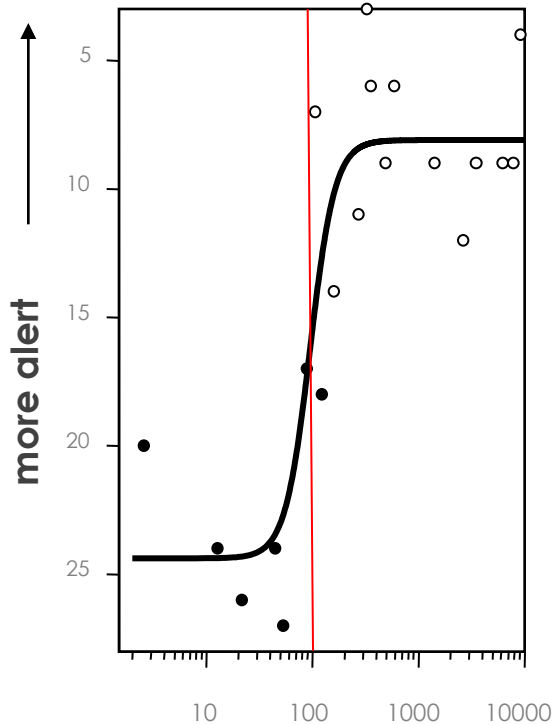


Light Intensity is Important!

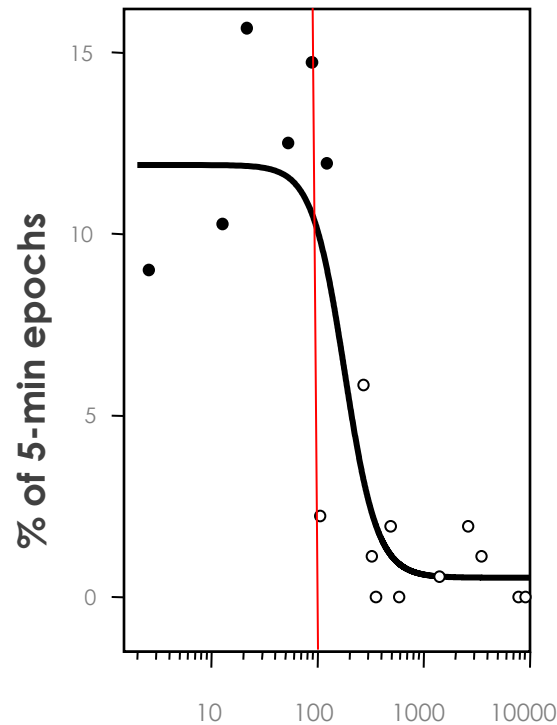


Dose-response curve to light

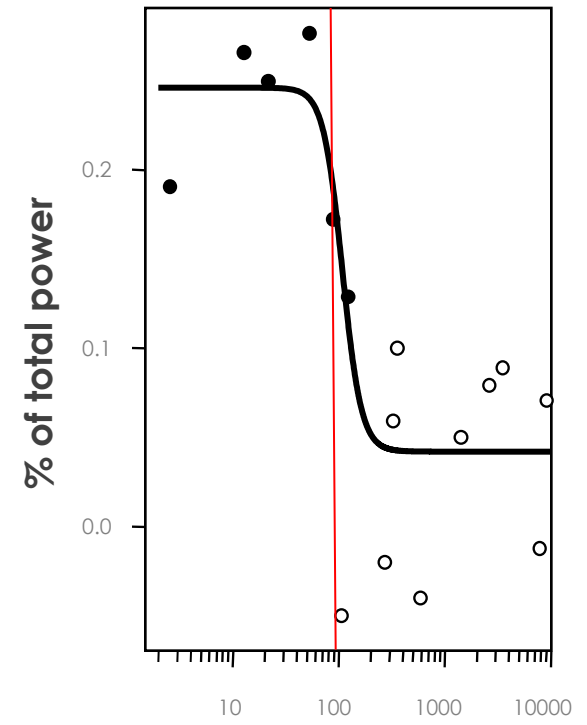
Subjective Alertness



Slow Eye Movements



EEG Power Density (5-9 Hz)



even more sensitive to blue light

Timing of Light Exposure is crucial

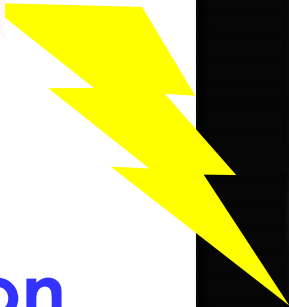
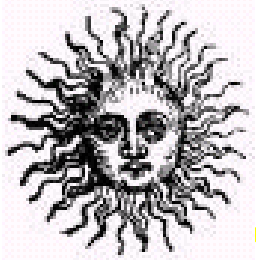
Morning light synchronises the biological clock to 24 hours

← Rhythms are advanced

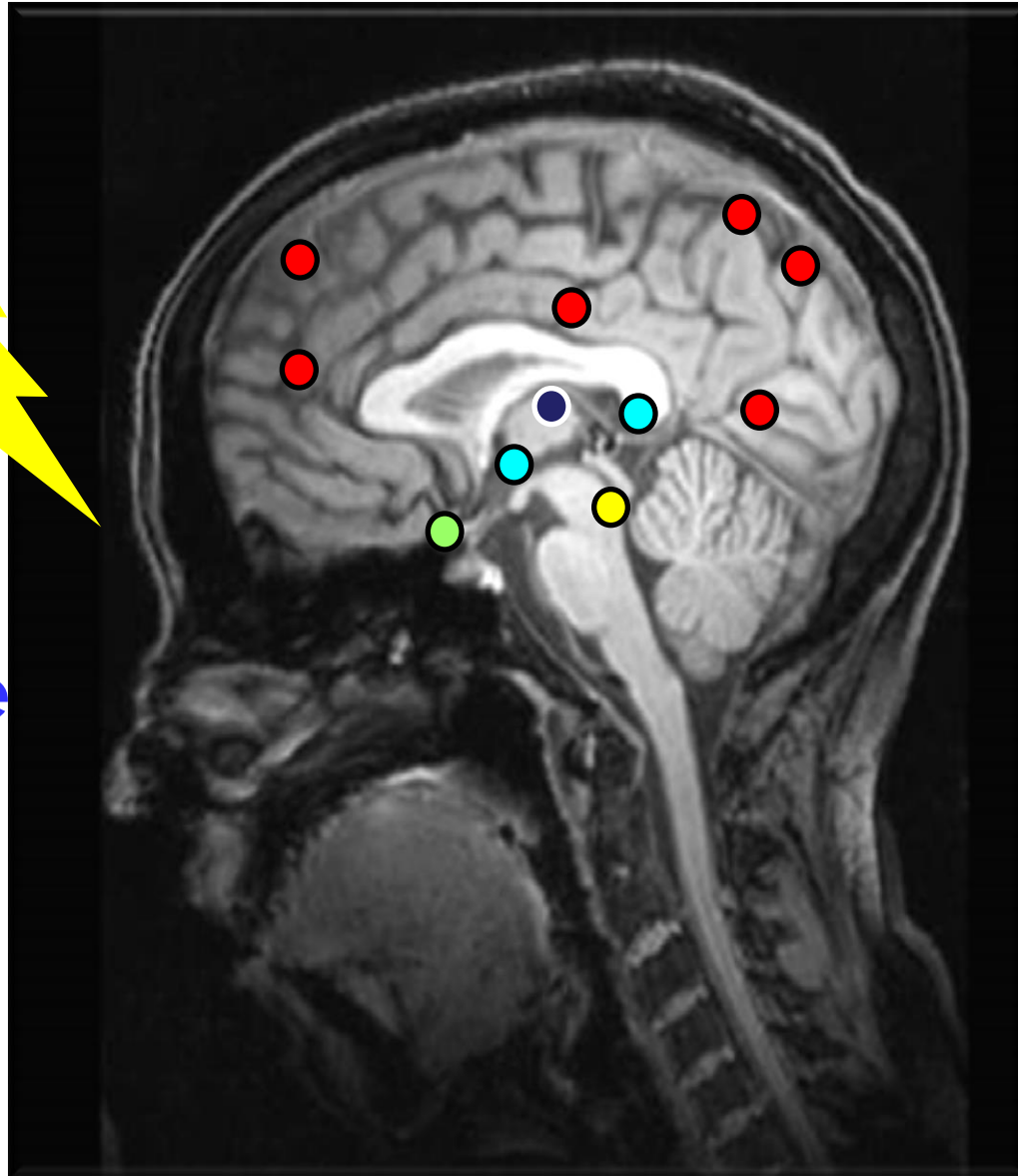
Evening light has the opposite effect

→ Rhythms are delayed

Non-visual effects of light are widespread



mood
cognition
alertness
performance
sleep



- Cortex
- Thalamus
- Hypothalamus
- Brainstem
 - Locus coeruleus
- Limbic system
 - Amygdala
 - Hippocampus

**Light therapy:
sensational
success
in fighting winter
depression**



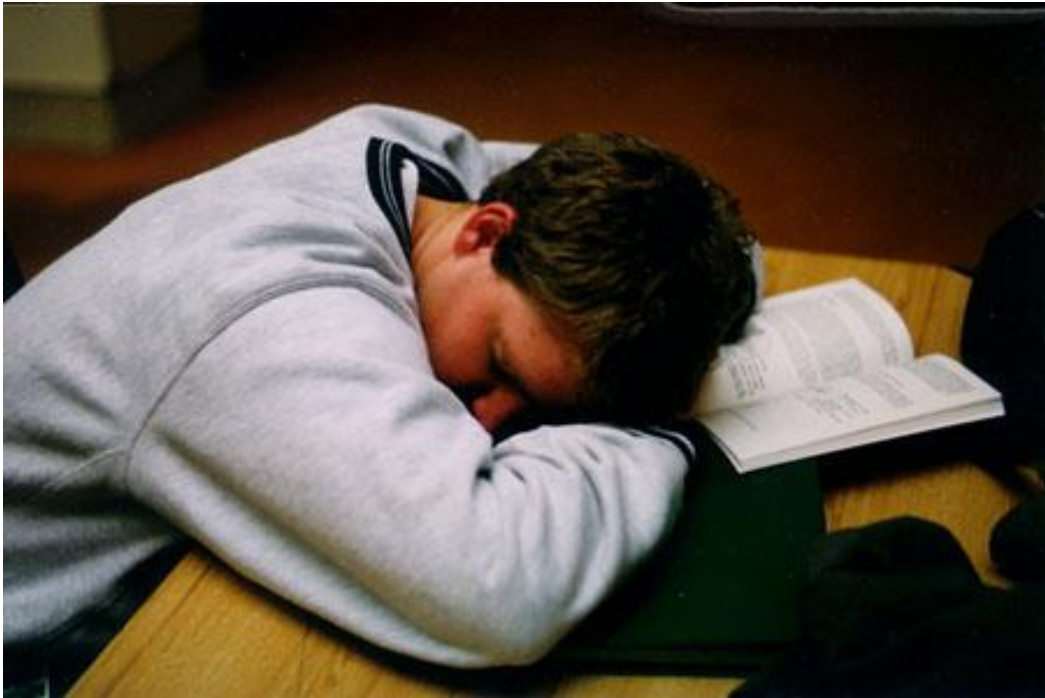
Light - how much, when, for whom?

Homes and work places may need to achieve 500 - 1000 lux in the direction of gaze. Energy saving conflicts with health, but not much energy is needed if light is near the eye, and limited to a short period in the morning.



"And the dim fluorescent lighting is meant to emphasize the general absence of hope."

Schoolkids don't see much morning light



Bright morning light needed by adolescents and young adults, as soon after getting up as possible. School rooms may be too dark: 500 – 1000 lux would help.

OR: more natural: later school times

OR: blue-blocking glasses in the evening

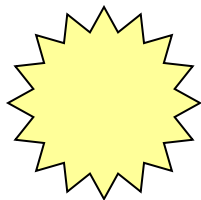


Older persons don't see evening light very much



Evening light may be important, e.g. while watching TV. Living rooms are too dark. Since the average is 30 lux, small improvements might help.

Architecture modifies length of hospitalisation in depressive patients

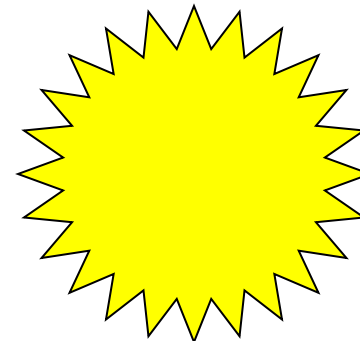
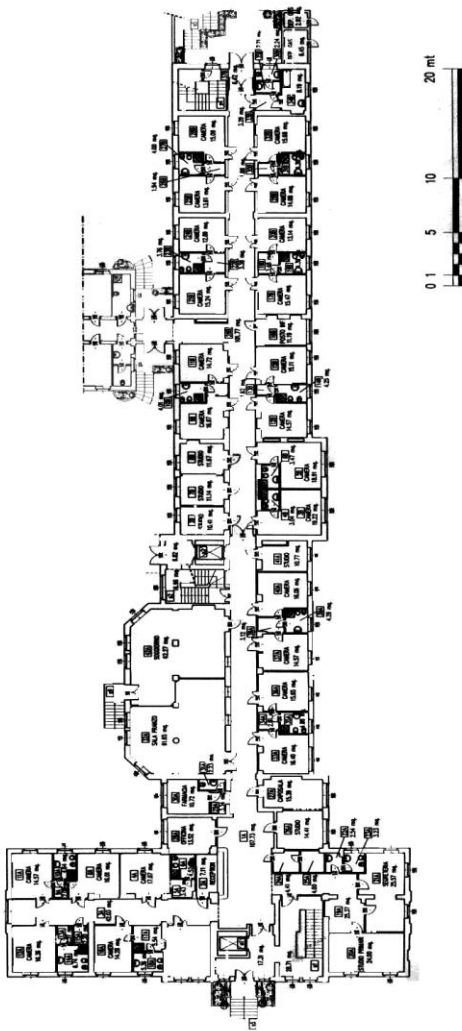


West

Morning: 1400 lux

Afternoon: 3000 lux

23.5 days (N=74)



East

Morning: 15500 lux

Afternoon: 2700 lux

20 days (N=113)

Dying in the Dark

Outcome on a cardiac intensive care unit after heart attack (N= 628)

length of stay mortality



sunny rooms 2.3 days 7.2%



dull rooms 3.3 days 11.6%

Enhancing light intensity in nursing homes

before...

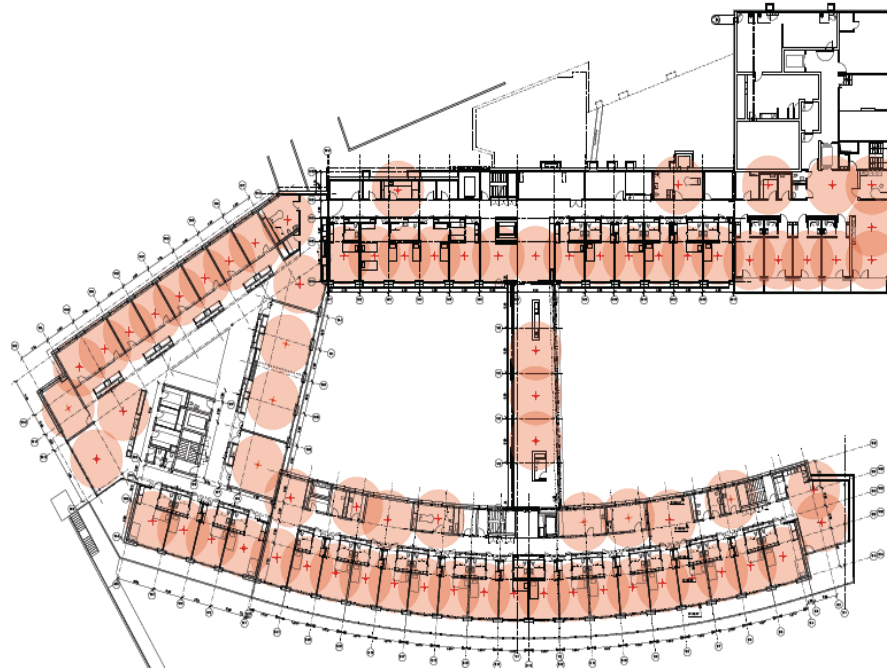


after...



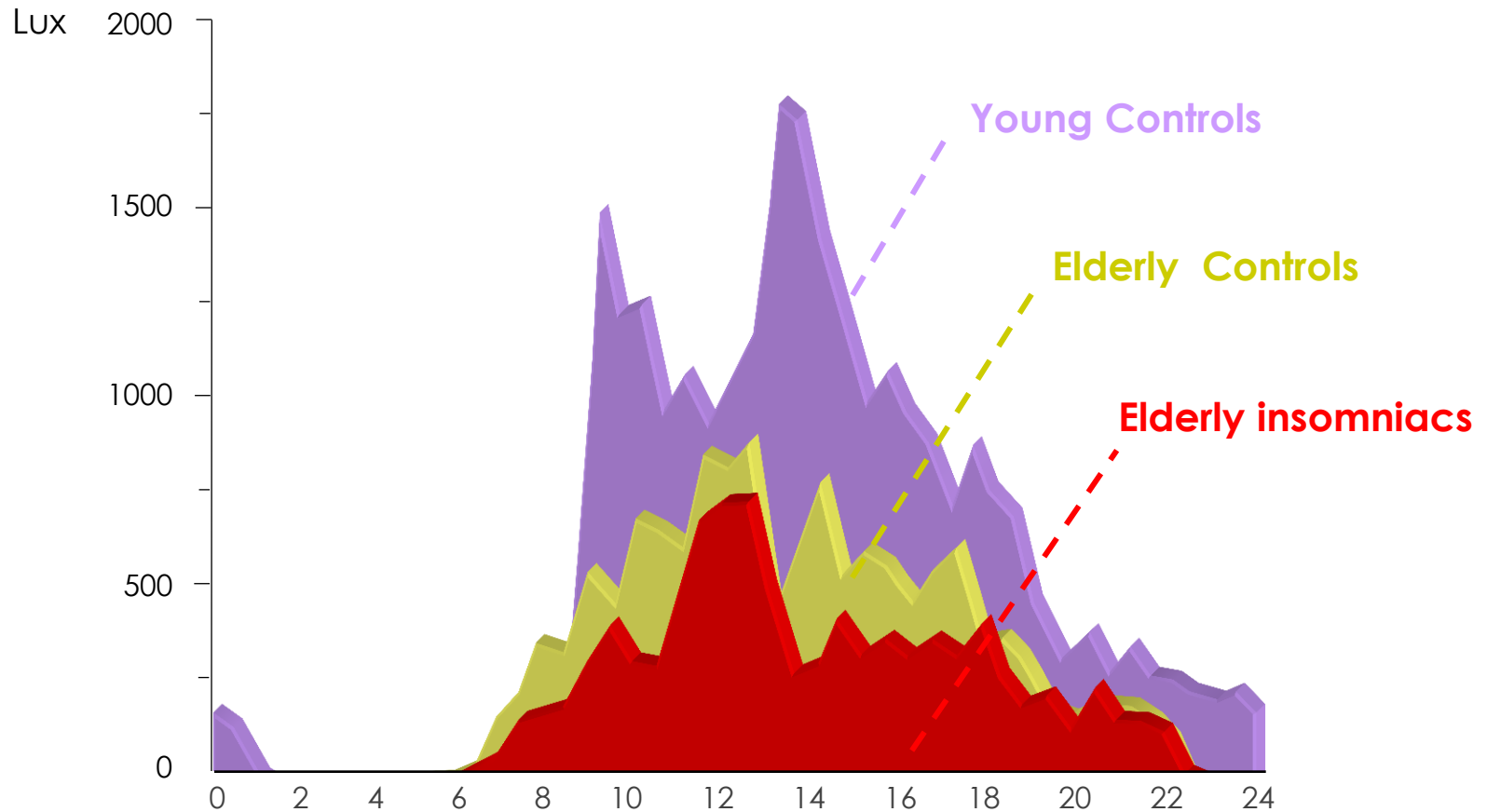
- Slows down cognitive decline
- Increases 24-hr activity rhythm amplitude
- Reduces incidence of depression
- Improves capacities for daily living

Retirement homes: lighting design must include circadian components to enhance sleep quality, wellbeing, health

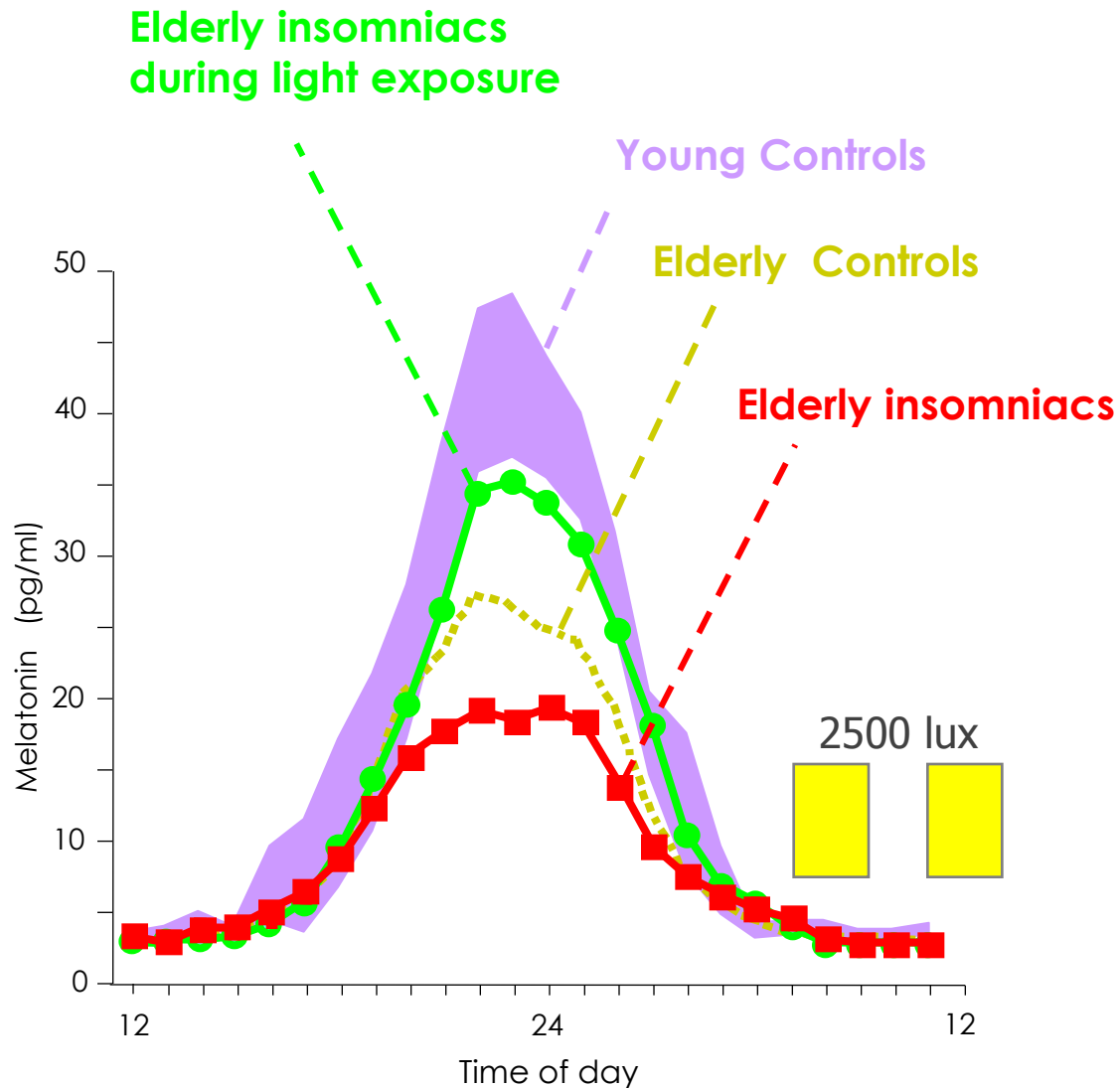


Older persons with sleep problems spend less time in daylight

Daily profile of light exposure at eye level



Circadian rhythm of melatonin



Light-Dark / Day-Night cycle

**important for health
and recuperation**

- intensive care**
- neonatal baby unit**
- paraplegic unit**
- oncology practice**
- nursing homes**

Entrainment needs light



**Get half an hour a day outdoors !
Most of the population gets less !!!**

The First Law of Chronobiology

rhythms better - sleep better -

think better – feel better –

behave better

ENTRAINMENT !

The Second Law of Chronobiology

Zeitgebers

Zeitgebers

Zeitgebers

Zeitgebers

more light ! more darkness !

Effects of light on performance, mood, and health occur through the simultaneous action (and interaction) of various CNS pathways

When we talk about the effects of light on well-being, it is important to remember that there are several other pathways still waiting for more thorough investigation. Despite all the important advances thus far, we're a long way from having all the answers about how light affects physiology and psychology.

We've come a long way in a decade

- Discovery of a novel photoreceptor
- Importance of light for non-visual photic function
- Far broader effects than just on the circadian clock – impacts general health and wellbeing
- **Research is still ongoing – lots of surprises ahead, too early for laying down rules**
- **LEDs (and new development of OLEDs) - unique opportunities to programme lighting spectra, intensity and timing to mimic daylight and enhance function**

Entrainment by light: what do we need?

sunlight?



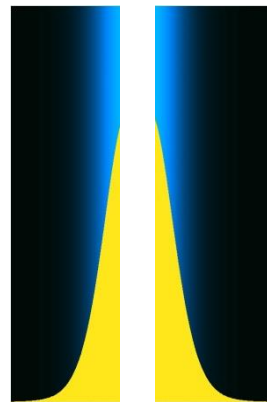
white light?



blue-enhanced light?



dynamic lighting? dawn-dusk simulation?



Many questions & many answers
& many more questions...

e.g. is blue better? But blue-enriched office light competes with natural light as a zeitgeber

e.g. is more light better? Yes, but not sufficient to improve infrastructure - requires active exposure to light

...depends on situation

Circadian Rhythms and Health what is important?

Stable internal and external phase relationships

- **appropriate entrainment to the light-dark and sleep-wake cycle**
- **enough light, enough darkness**
- **adequate retinal function**
- **sufficient social zeitgebers**
- **reconsider the zeitgeber function of timed activity and meals**



**So what will the Circadian House
of the future look like?**

Watch this space.....!



26th Annual Meeting

Society for Light Treatment & Biological Rhythms



Symposia

- Clocks, Sleep & Mood Disorders
- Direct Neuro-Biological Effect of Light
- Light in the Elderly

June 27-29, 2014

Venue: Schloss Schönbrunn- Vienna

Hotel: Courtyard Marriott, Vienna

SLTBR President & Local Host

Matthäus Willeit, MD

Department of Biological Psychiatry
Medical University Vienna
Austria

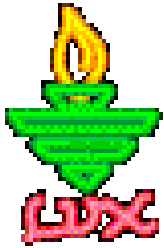


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www.sltbrmeeting.org

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Society for Light Treatment and Biological Rhythms



26th Annual Meeting June 27-29, 2014 Vienna

Teaching Course on Light Therapy

- Ins and Outs of Light Therapy for Circadian Sleep and Depressive Disorders
M.Terman (Columbia University, New York)
- The dark and bright side of light (on retinal photoreceptors)
F.Hafezi (University of Geneva)
- Various disorders that can be treated with light
A.Wirz-Justice (University of Basel)

Symposia

- Direct Biological and Behavioral Effects of Light
- Clocks, sleep and mood Disorders
- Chronobiology of Aging and Dementia

Keynote Lecture:

Retinal and brain circuits underlying the effects of light on mood

S. Hatter (Johns Hopkins University, Baltimore)

+ Oral presentations and posters