Light Quality, Metabolism and Health: Are we at risk from poor quality “junk” light?

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Four Part Series

• Week 1: Insulin and Inflammation
• Week 2: Leaky Gut and the Gut Biome
• Week 3: Sleep and Circadian Rhythms
• Week 4: Stress Response- Hypnosis Experience
Critical Considerations

1. Weight, metabolism and health appear tightly connected to our biologic synchronization with daily circadian rhythms.
2. Light interacts with human biology through our eyes and skin.
3. The timing and quality of our light and meal exposure appear to be of major influence on these rhythms.
4. Lifestyle changes can bring greater alignment to these critical relationships as an opportunity for improved health, disease prevention and disease management.
The Origins of Health Systems Biology

**Disease (how things appear)**
- Pre-diabetes
- Diabetes
- Weight
- HBP
- Lipids
- Heart Disease
- Stroke
- Depression
- Autoimmunity
- Arthritis
- Alzheimer’s
- Cancer
- Fibromyalgia
- Chronic fatigue

**Core Metabolic Imbalances (what drives them)**
- Inflammation
- Insulin Resistance
- Gut-Barrier Function/Microbiome
- Circadian Entrainment
- Stress Response

**Root Causes (what are their origins)**
- Environment+Epigenome/genes+Microbiome
- Nutrition
- Movement
- Stress Response
- Environmental toxins
- Sleep
- Social Connection
- Trauma
- Conflict Management
- Forgiveness
- Mindfulness
- Spirituality
- Meaning
- Medications
- Light quality-entrainment

A disrupted clock: decreased sleep quality, mood, metabolism, cardiovascular health. Increased risk for disease.

Behavior that decreases circadian health & delays healthy aging:
- Shift work
- Jet lag
- Aging
- Erratic lifestyle

Behavior to improve circadian health & promote healthy aging:
- Time-restricted feeding
- Healthy light exposure
- Regular and sufficient sleep

Satchin Panda PhD, Salk Institute
**zeitgeber** | a cue given by the environment, such as a change in light or temperature, to reset the internal body clock. from German Zeitgeber, from Zeit ‘time’ + Geber ‘giver’.

Too little of this:

Too much of this:
• Earth, at the equator is spinning approximately 1,000 miles/hour around its axis
• Earth is orbiting the sun, moving approximately 66,600 miles/hour
• Diurnal rhythm is central to the existence of all life on our planet
If you want to find the secrets of the universe, think in terms of energy, frequency and vibration.

~ Nikola Tesla
Hippocrates prescribed heliotherapy (sunbathing) for both medical and psychological purposes. Philostratus claimed that all of the Olympian athletes took sunbaths in order to strengthen their muscles and bones.
1903

Niels Ryberg Finsen (1860-1904)

Danish physician.

Nationality - Denmark

- The 1903 Nobel prize in Physiology or Medicine was awarded to Niels Ryberg Finsen "in recognition of his contribution to the treatment of diseases, especially lupus vulgaris, with concentrated light radiation, whereby he has opened a new avenue for medical science."
Princess of Wales donates Finsen lamp to the London Hospital 1900

Tuberculosis - the Lamps of Hope

During the 1890s, Niels Ryberg Finsen (1860-1904), a Danish physician, investigated the bactericidal effects of light which he found was more effective at the ultra-violet end of the spectrum. He constructed a powerful carbon arc electric lamp with four tubes down which light was passed.

Finsen's results at treating lupus were so successful that in 1896, the Finsen Institute was set up in Copenhagen and by the turn of the century, 500 patients had been treated.
1931 US GOVERNMENT PROVIDED RECOMMENDATIONS FOR SUN EXPOSURE
Light Therapeutics

A Practical Manual of Phototherapy for the Student and the Practitioner

With Special Reference to the Incandescent Electric-Light Bath

BY J. H. KELLOGG, M. D.

Author of "Bacterial Hydrotherapy," "The Art of Massage," etc. Member of the British Gynæological Society, the International Scientific Congress of Gynæology and Obstetrics, American and British Associations for the Advancement of Science, the Société d'Hygiène de France, American Society of Microscopists, American Climatological Society, American Medical Association, Michigan State Medical Society, Superintendent of the Battle Creek (Mich.) Sanitarium

BATTLE CREEK, MICH.
THE GOOD HEALTH PUBLISHING CO.
Publisher of Therapeutic Manuals
1899
The “Billi Blanket”
The 2017 Nobel Prize in Physiology or Medicine

Jeffrey C. Hall
Born in New York, USA in 1945

Michael Rosbash
Born in Oklahoma City, USA in 1944

Michael W. Young
Born in Miami, USA in 1949

for their discoveries of mechanisms controlling circadian rhythms
Shift Work: Disrupted Circadian Rhythms and Sleep—Implications for Health and Well-being

Stephen M. James¹,² • Kimberly A. Honn¹,² • Shobhan Gaddameedhi¹,³ • Hans P.A. Van Dongen¹,²
CLINICAL REVIEW

Sleep loss, circadian disruption → STRESS RESPONSE → GUT MICROBIOTA
- Modified colonies
- Elevated bacteroidetes
- Gut microbial dysbiosis

INFLAMMATION
- ↑ gut permeability

METABOLIC DISRUPTION
- Obesity, type II diabetes, metabolic syndrome
Cortisol and Melatonin Diurnal Rhythm
Desire Color Rendering Index (CRI) 95+ %
Color Temperature 2700-3000k
Global rise of potential health hazards caused by blue light-induced circadian disruption in modern aging societies

Megumi Hatori, Claude Gronfier, Russell N. Van Gelder, Paul S. Bernstein, Josep Carreras, Satchidananda Panda, Frederick Marks, David Sliney, Charles E. Hunt, Tsuyoshi Hirota, Toshiharu Furukawa, and Kazuo Tsubota

Mammals receive light information through the eyes, which perform two major functions: image forming vision to see objects and non-image forming adaptation of physiology and behavior to light. Cone and rod photoreceptors form images and send the information via retinal ganglion cells to the brain for image reconstruction. In contrast, nonimage-forming photoresponses vary widely from adjustment of pupil diameter to adaptation of the circadian clock. Nonimage-forming responses are mediated by retinal ganglion cells expressing the photopigment melanopsin. Melanopsin-expressing cells constitute 1–2% of retinal ganglion cells in the adult mammalian retina, are intrinsically photosensitive, and integrate photic information from rods and cones to control nonimage-forming adaptation. Action spectra of ipRGCs and of melanopsin photopigment peak around 480 nm blue light. Understanding melanopsin function lets us recognize considerable physiological effects of blue light, which is increasingly important in our modern society that uses light-emitting diode. Misalignment of circadian rhythmicity is observed in numerous conditions, including aging, and is thought to be involved in the development of age-related disorders, such as depression, diabetes, hypertension, obesity, and cancer. The appropriate regulation of circadian rhythmicity by proper lighting is therefore essential. This perspective introduces the potential risks of excessive blue light for human health through circadian rhythm disruption and sleep deprivation. Knowing the positive and negative aspects, this study claims the importance of being exposed to light at optimal times and intensities during the day, based on the concept of the circadian clock, ultimately to improve quality of life to have a healthy and longer life.

npj Aging and Mechanisms of Disease (2017)3:9 ; doi:10.1038/s41514-017-0010-2
How exposure to **blue light** affects your brain and body

The disruption to your sleep schedule might leave you distracted and impair your **memory** the next day.

A poor night’s sleep caused by smartphone light can make it **harder to learn**.

Over the long term, not getting enough sleep can lead to **neurotoxin** buildup that makes it even harder for you to get good sleep.

People whose melatonin levels are suppressed and whose body clocks are thrown off by light exposure are more prone to **depression**.

By disrupting melatonin and sleep, smartphone light can also mess with the hormones that control hunger, potentially increasing **obesity risk**.

There’s some evidence that blue light could damage our vision by harming the **retina** over time – though more research is needed.

Researchers are investigating whether or not blue light could lead to **cataracts**.

There’s a connection between light exposure at night and the disturbed sleep that come with it and an increased risk of breast and prostate **cancers**.

**Sources:** Nature Neuroscience; Harvard Health Publications; ACS, Sleep Med Rev, American Macular Degeneration Foundation; European Society of Cataract and Refractive Surgeons; JAMA Neurology
Blue Light at Night Suppresses Melatonin and Damages Health

Circadian Clock Suprachiasmatic Nucleus (SCN)
Cortex
Pineal Gland
Optic Nerve
Retinal Photoreceptors

 SCN “Circadian Clock”

Detected by Melanopsin Photoreceptors
Transmitted by Non-Visual Light Pathways

4 mW/cm² blue light bio-equivalent to 100 mW/cm²

Pituitary-Adrenal Axis
Cortisol Elevated
Brainstem Arousal Centers
Circadian Timing System

Increases Breast & Prostate Cancer Risk
Increases Obesity & Diabetes Risk
Sleep Disruption & Fatigue
Circadian Disruption, Jet-Lag & Depression

Aging and Mechanisms of Disease (2017) 3:9
Melatonin

- Hormone of darkness
- Very sensitive to blue light
- Facilitates sleep cycle
- Increases cell regeneration
- Anti-oxidant activity; ROS scavenger
- Antagonizes Aromatase and lowers estrogen production in tissues
- Modulates immune regulatory function
- Antagonizes cortisol
- Key substance for chronobiologic adaptation (day/night and summer/winter)
BLUE LIGHT CREATES VISUAL BLUR

Courtesy Dr. Alexander Wunsch
Fluorescent Light/
Night Shift Work

- NHS- Nurses Health Study (Harvard)
- 120,000 nurses followed 30+ years
- 30-50% increase of breast cancer after 15 years of night work
- Higher rates of obesity, diabetes, heart disease and depression
• Author of the UV Advantage
• Sunblocks with factor 15+ reduce Vitamin D by 99.9%
• More thoughtful dosed sunlight exposure e.g. 30-60”/day could reduce cancer incidence in USA by as much as 50%
• Melanoma risk significantly reduced with occupational sun exposure
Cannot Make Vitamin D In Winter Above 32 N
Vitamin D and Reduced Risk of Breast Cancer: A Population-Based Case-Control Study

Julia A. Knight,¹ Maia Lesosky,¹ Heidi Barnett,¹ Janet M. Raboud,¹ and Reinhold Vieth²

Table 2. ORs and 95% CIs for an association between vitamin D–related exposure variables at ages 10 to 19 (sun exposure and dietary vitamin D) and breast cancer in cases and controls

| Girls 10-19 yrs most sun ↓69% |
|---|---|
| OR (95% CI) | OR (95% CI) |
| 1.00 (1.00) | 1.00 (1.00) |

Table 3. ORs and 95% CIs for an association between vitamin D–related exposure variables at ages 20 to 29 (sun exposure and dietary vitamin D) and breast cancer in cases and controls

| Women 20-29 yrs most sun ↓51% |
|---|---|
| OR (95% CI) | OR (95% CI) |
| 1.00 (1.00) | 1.00 (1.00) |

| Women 45-54 yrs most sun 0.0% |
|---|---|
| OR (95% CI) | OR (95% CI) |
| 1.00 (1.00) | 1.00 (1.00) |

Courtesy Michael Holick MD, PhD
Sunlight enters through your eyes.

Acting through the hypothalamus, sunlight regulates our circadian rhythm through complex pathways that include melatonin, serotonin and body temperature.

Improving your circadian rhythm has dramatically positive effects on your body and mood.

MORE ENERGY

IMPROVED MOOD

BETTER SLEEP AT NIGHT
Full-spectrum light box: 10,000 lux
Intermittent Fasting
Eating pattern in Anthropogenic world

Duration of eating: 50% eat for 15 h or longer
Weekend jet lag: 47% delay or advance breakfast by $1h$ in weekends
Eating Frequency: 25% food are eaten within 1.5 h of previous meal
<25% food is consumed before noon.
>36% of food is consumed after 6pm.
~100% of maintenance calories is consumed within a 12 h period.
Intermittent Fasting
Time Restricted Eating (TRE)

- Time restricted feeding e.g. consume all food within 10-hour window. No eating 2-3 hrs before bedtime
- Excellent Circadian rhythm “calibration”
- Decreases in body weight and visceral fat, insulin and glycemic control
- Significant reductions in breast cancer recurrence and improved prognosis (Patterson et al. UCSD 2016)
- Improved cardiovascular disease risk profile
- Decreased neuroinflammation (Neurobiol Aging. 2015 May;36(5):1914-23)
- Improved sleep!!
Saunas

• Really good for health promotion and disease prevention
• Upregulates HSP, defense/resiliency mechanisms
• 30” minutes 3-4x/week
• Steam or infrared


Sleep Hygiene 101

- Consistent timing of sleep-wake
- Dark bedroom (eye mask)
- Cooler temperature (64-68)
- Reduce ambient noise (ear plugs)
- Obstructive sleep apnea underdiagnosed (neck circumference 16+” in women and 17+” in men)
- No caffeine after 2p
- Avoid eating within 2-3 hrs bedtime
- Phone/laptops on airplane mode or turned off
Zeitgebers: Circadian Entrainment

- Sleep hygiene
- Grounding...take your shoes off and stand outdoors
- 60” full spectrum outdoor lighting/day: within 2 hrs after sunrise and within 2 hours before sunset
- Give your retina access; no sunglasses at key times of day
- Evening light: Incandescent 2700k, Halogen 3,000k, warm LED on dimmer
- Orange-amber light at night
- Blue light filters 2-3 hrs before bedtime; F*Lux, Night Shift, Iris apps;
- Computer settings: lower color temperature
- Time Restricted Feeding: no eating within 2-3 hours of bedtime
- Movement during the daytime
- Social interactions during the day
- Stress during the day...not good after sunset

Satchin Panda, PhD  The Circadian Code
Continuous Self-Improvement  PDSA Virtuous Cycle

- Consider Light Box
- Change CFUs to warm LEDS

ACT
Make another small change

PLAN
Plan your small change

STUDY
What impact did this small change have?

DO
Implement this small change

- 30-60” full-spectrum light each day
- Reduce Blue light at night

- Walk outdoors
- Sit-lunch outside
- Sit near windows
- Blue light filters
- Incandescent/halogen bulb in family room/bedroom

- Journal response to stressors for 10” at end of day
- Sleep
Thank you!
Red-IR (600-2000nm)

- Mitochondrial function
- Hair regrowth
- Allergic rhinitis (Israel)
- MS (UWisconsin 2012)
- Skin, collagen
- Degenerative Neurologic Diseases (2010 Kanazawa University Japan; 2012 University of Cambridge)
- Health benefits IR sauna

Immunity around the clock

Circadian clocks: Not your grandfather's clock
Fred M. Turek

The last 20 years have seen the rapid evolution of our understanding of the biology of circadian rhythms. The discovery of the mammalian circadian timing system resulted in the identification of gene networks that generate circadian periodicity in a 24-hour time frame. One finding has been particularly important: the circadian clock is a timekeeper that governs the timing of many cellular and organ functions, including sleep, metabolism, and the immune system. This has opened the door for new therapies to treat sleep disorders, metabolic diseases, and infections.

Mechanisms linking circadian clocks, sleep, and neurodegeneration
Erik H. Mossbauer and David M. Roderick

Aberrations of normal circadian rhythms and sleep cycles are consequences of aging and can profoundly affect health. Accumulating evidence indicates that circadian and sleep disorders, which have long been considered symptoms of many neurodegenerative conditions, may actually drive pathogenesis early in the course of these diseases. In this review, we explore potential cellular and molecular mechanisms that link circadian rhythms to neurodegeneration and discuss possible therapeutic implications. The circadian clock and sleep influence a number of key processes involved in neurodegeneration, suggesting that these systems might be targeted to promote healthy brain aging.

Circadian time signatures of fitness and disease
Matthew Reiner and Mitchell A. Lazar

Biological clocks are autoregulatory oscillators that play a critical role in the organization and functioning of many biological processes, including metabolism, immune function, and circadian rhythms. In this review, we explore the molecular mechanisms through which circadian clocks regulate energy metabolism and their potential therapeutic implications. We discuss how circadian rhythms influence the body's response to different metabolic challenges and how these rhythms can be harnessed to improve health and disease outcomes.

Circadian physiology of metabolism
Antonio Paolisso

A minority of mammalian genes exhibit daily fluctuations in expression levels, making circadian expression rhythms the largest known regulatory network in mammalian cells. Circadian rhythms in expression levels of thousands of genes, transcribed during the light phase and translated during the dark phase, control different physiological functions, including metabolism, insulin sensitivity, and fat accumulation. Circadian expression of genes involved in lipid metabolism and energy homeostasis is tightly controlled by the circadian clock, which in turn, regulates metabolic processes. Circadian rhythms in energy metabolism are essential for the proper function of the endocannabinoid system, which mediates the homeostatic control of energy balance. Furthermore, time-restricted feeding, which improves daily cycles of feeding and fasting without calorie reduction, sustains reduced diurnal rhythms and can alleviate metabolic diseases. These findings highlight an integrative role of circadian rhythms in physiology and offer a new perspective for treating chronic diseases in which metabolic dysfunction is a hallmark.
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UV: UV radiation; blue: blue light; infrared: infrared radiation.
Light

Suprachiasmatic Nucleus (SCN)

Output Rhythms:
- Physiology
- Behavior
TOPICAL REVIEW

Time-restricted feeding for prevention and treatment of cardiometabolic disorders

Girish C. Melkani\textsuperscript{1} and Satchidananda Panda\textsuperscript{2}

\textsuperscript{1}Department of Biology, Molecular Biology and Heart Institutes, San Diego State University San Diego, CA 92182, USA
\textsuperscript{2}Regulatory Biology Laboratory, Salk Institute for Biological Studies, La Jolla, CA 92037, USA
Misalignment with the external light environment drives metabolic and cardiac dysfunction.