

Light for health: Defining how light affects development and function of the brain and sensory systems.

Wayne Davies

Emanuel Holm



Erika Rasmuson

Anna-Carin
Hägglund

Karhi Ramanujam



UMEÅ UNIVERSITY

Prof. Lena Gunhaga

lena.gunhaga@umu.se

Sun-Coupled Physiology

Visual System

Light entrained circadian clocks

Energy homeostasis

This is the lighting in which we choose to live:



*Many live in opposition
to our physiology*

Light exposure and health outcome

Increased disease risk associated with season-of-birth/conception.

Note 6 months shift between Northern and Southern hemispheres.

Condition	J	F	M	A	M	J	J	A	S	O	N	D	Ref
General pathologies													
Crohn's disease (Israel)		■										■	[105]
Childhood diabetes mellitus			■	■	■	■							[106]
Glaucoma				■	■	■	■						[107]
Hodgkin disease		■	■										[108]
Psychiatric disorders													
Alcohol abuse				■	■	■	■						[42]
Autism				■	■	■	■	■					[42]
Bipolar		■	■	■	■								[42]
Eating disorder			■	■	■								[42]
Personality disorder				■	■	■	■						[42]
Neuroses		■	■	■	■								[42]
SAD				■	■	■	■						[42,109]
Schizoaffective disorder		■	■										[42]
Schizophrenia (N. hemisphere)		■										■	[42,109–112]
Schizophrenia (S. hemisphere)						■	■	■	■				[110,111]
Suicidal behaviour (W. Australia)									■	■	■		[113]
Neurological illness													
Alzheimer's disease		■	■										[42]
Amyotrophic lateral sclerosis				■	■	■	■						[66]
Down's syndrome						■	■	■					[42]
Epilepsy		■	■	■	■							■	[66]
Mental retardation				■	■	■	■						[42]
Motor neuron disease				■	■	■	■						[42]
MS (Northern hemisphere)				■	■	■	■						[46,66,109,114]
MS (Southern hemisphere)										■	■	■	[46]
Narcolepsy		■	■	■	■								[115]
Parkinson's disease				■	■	■	■						[42,66,109]

Foster & Roenneberg,
Curr. Biol. 2008

Light exposure in relation to latitude and health outcome

BMJ



BMJ 2014;348:g2035 doi: 10.1136/bmj.g2035 (Published 1 April 2014)

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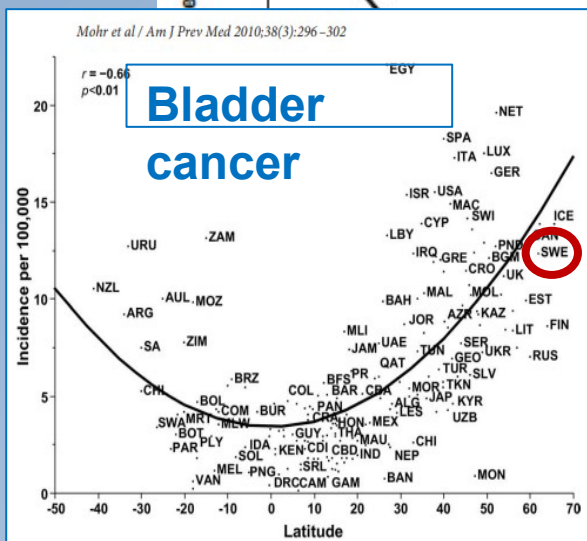
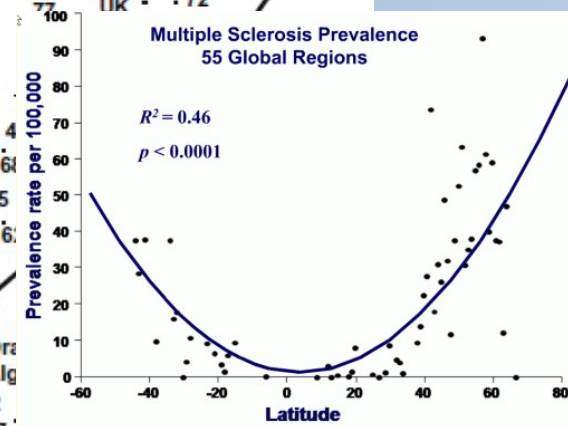
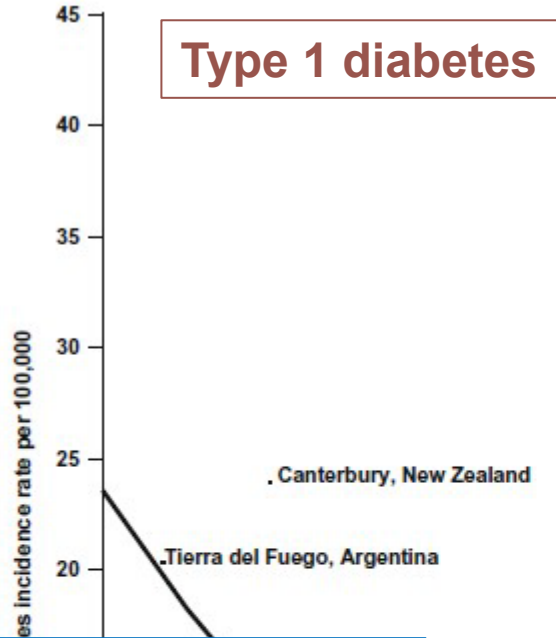
Vitamin D a biomarker for sunlight exposure.

RESEARCH

Vitamin D and multiple health outcomes: umbrella review of systematic reviews and meta-analyses of observational studies and randomised trials

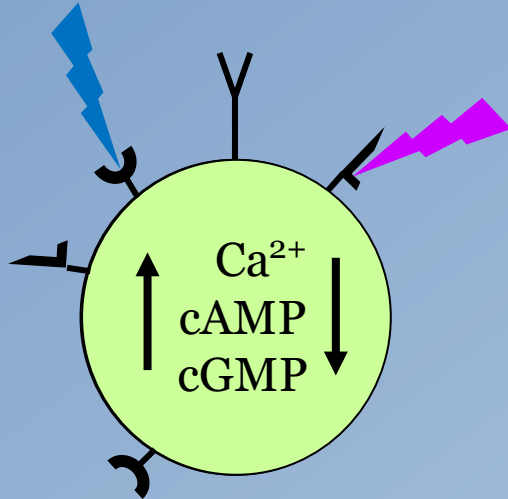
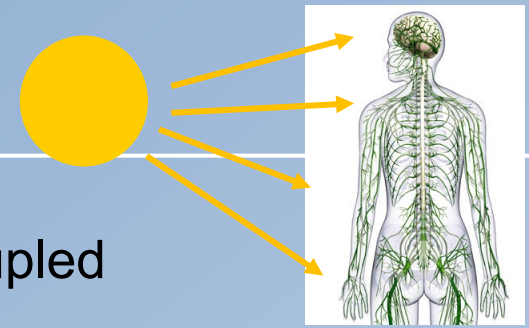
OPEN ACCESS

Evropi Theodoratou *research fellow*¹, Ioanna Tzoulaki *lecturer*^{2,3}, Lina Zgaga *associate professor*², John P A Ioannidis *professor*^{3,6}



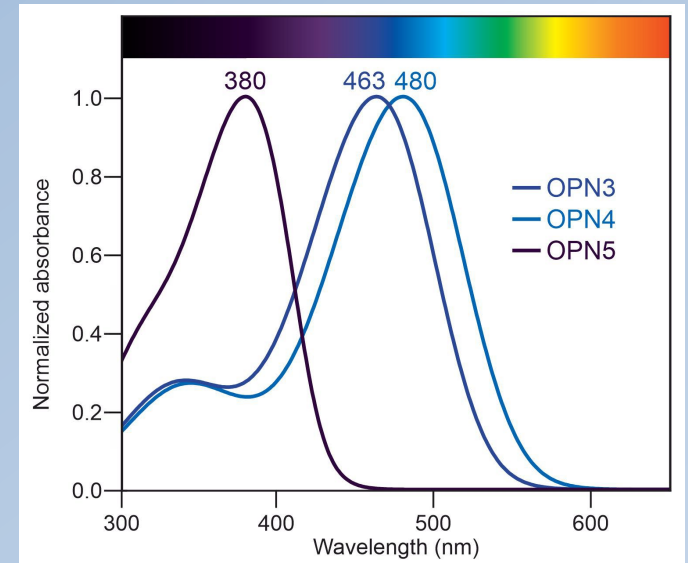
Mohr et al, Diabetologia, 2008

Opsins act as photoreceptors



- Opsins are G-protein coupled receptors that can act as photoreceptors.
- Opsins respond to light by transforming absorbed photon energy into cellular signals.

➤ Determine the function of non-visual opsins (OPN3, OPN4, OPN5) for the development and function of the brain, and sensory systems.



Previous and present aims (EELYS)



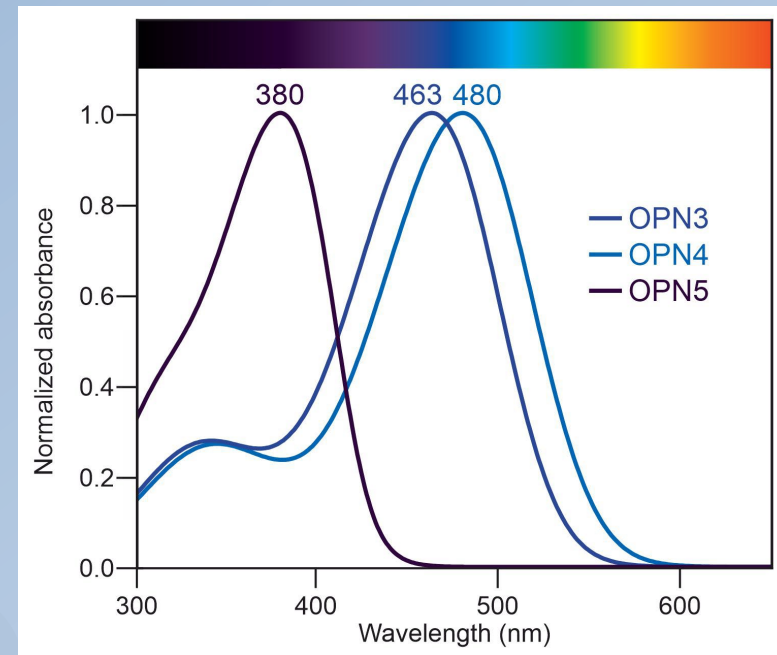
A1. Opn3, Opn4 and Opn5 expression patterns in the brain and sensory systems.

A2. Roles of Opn3, 4 and 5 in the developing and adult functional brain and sensory systems.

A3. Impact of light-dark rhythms on brain and sensory system development independent on the mother.

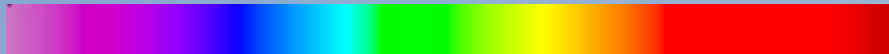
A4. Determine light exposure to preterm infants at the NICU, Umeå.

A5. Measure photon penetrance in various tissue types.



Major methods

Mouse

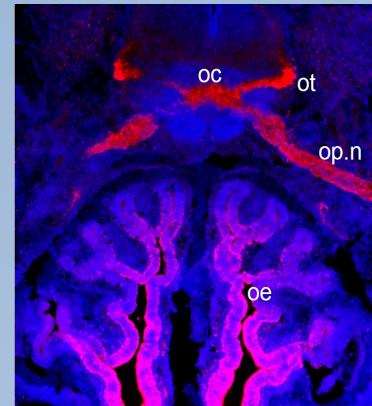


OPN3 KO
OPN4 KO
OPN5 KO

Chick



2D and 3D imaging



Behavior tests

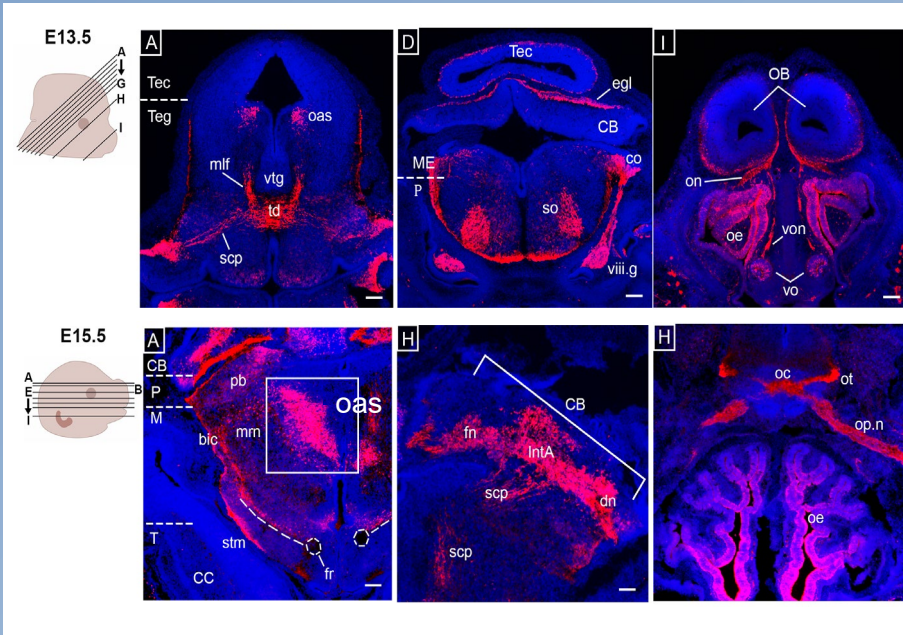


Shared by
Prof. Richard Lang, USA



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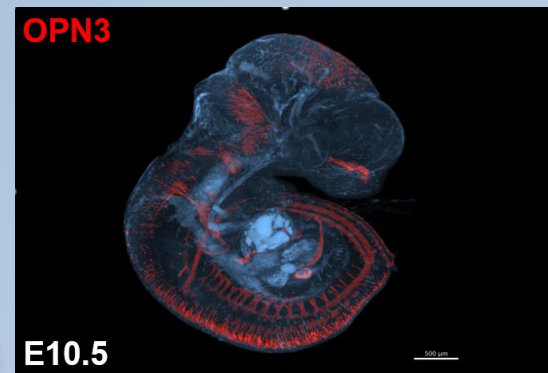
Mapped expression patterns of OPN3



Red = Opn3+ cells. Blue = all cells

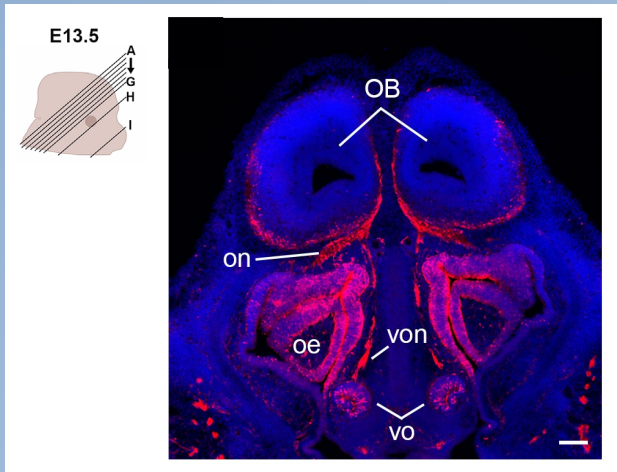
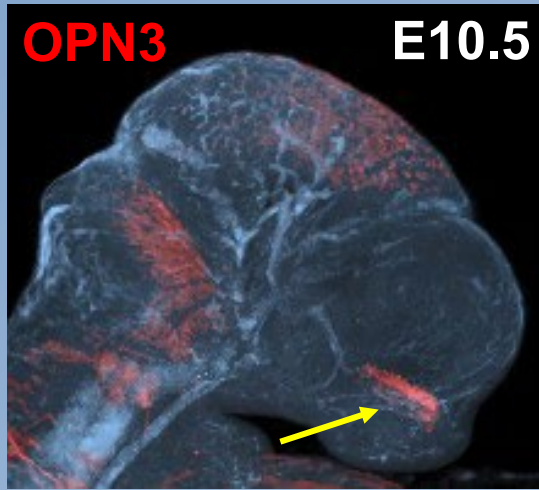
- Identified 100 Opn3 positive structures of which 25 are novel.
- Most with an onset at embryonic stages.
- Opn3 expression maintained and expanded at postnatal and adult stages.

Davies et al., 2021, eNeuro

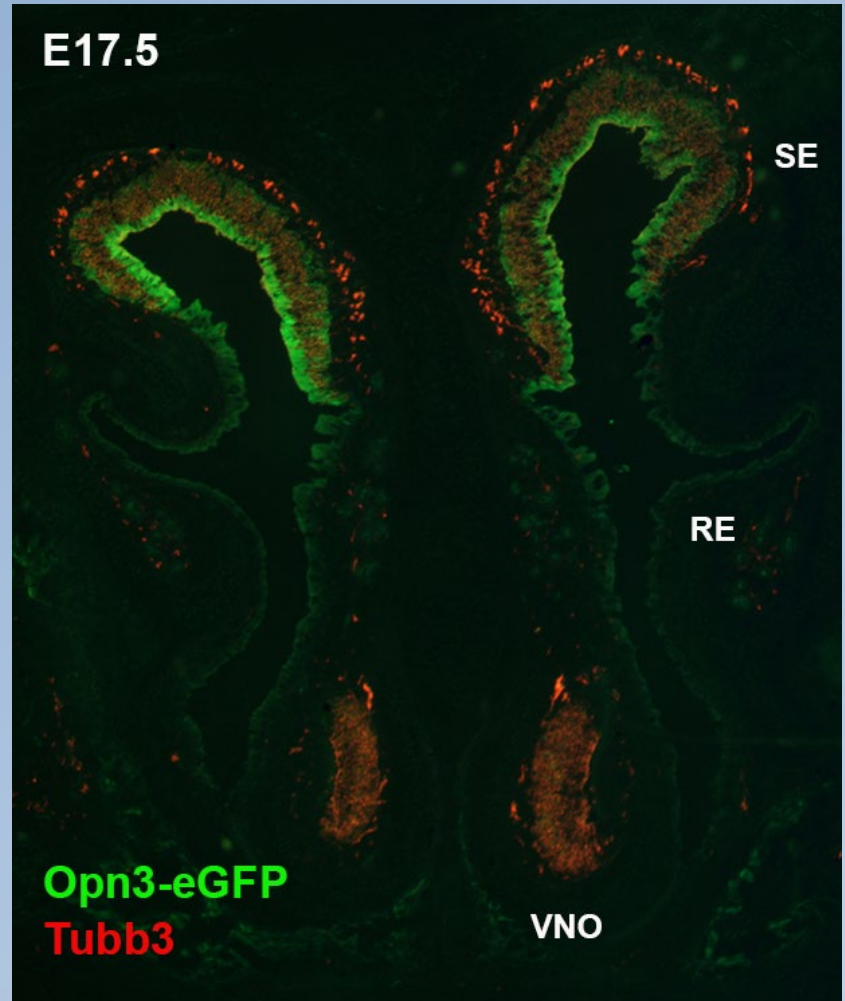


3D Optical Projection Tomography

Onset of OPN3 at embryonic stages in olfactory structures



Davies et al., 2021, eNeuro



- Preliminary data: OPN3 is expressed in olfactory sensory cells

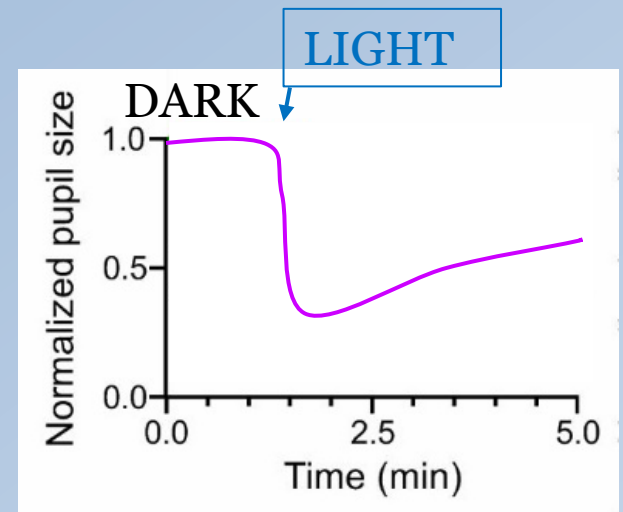
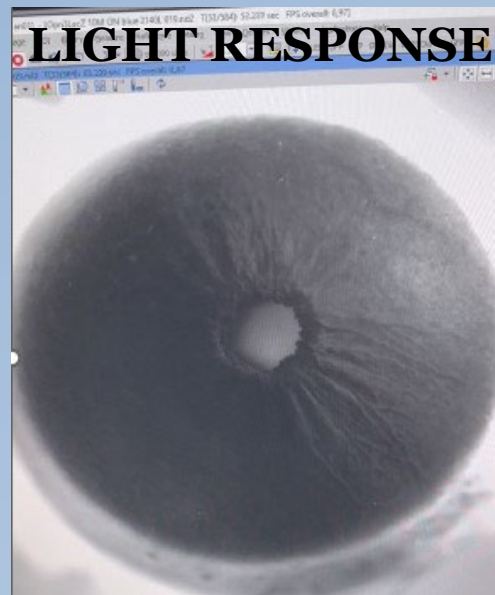
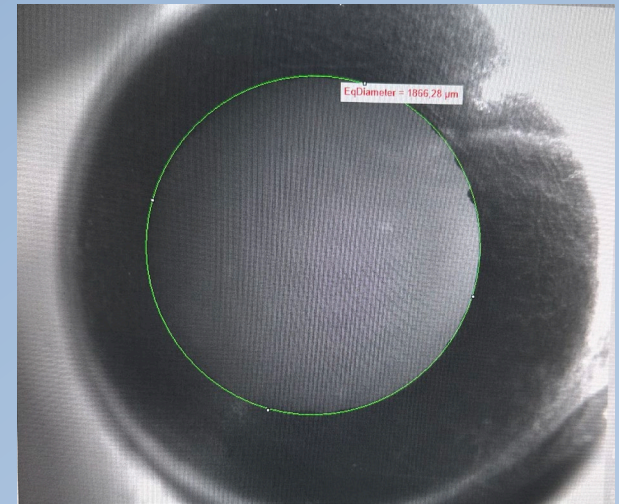
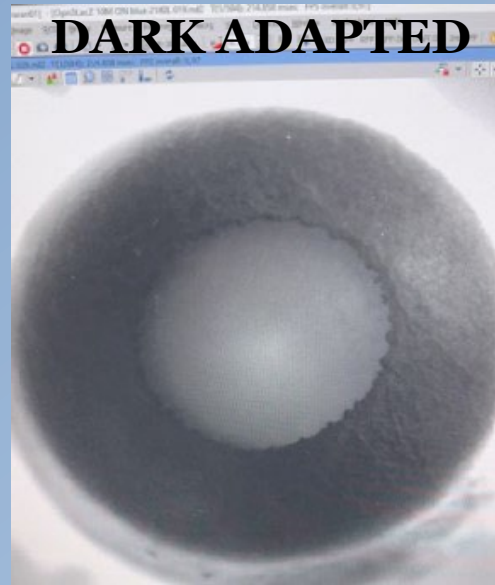
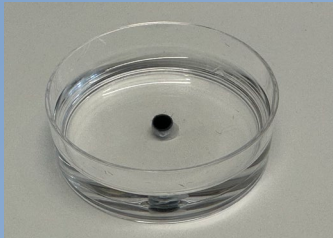
No apparent difference in olfaction between OPN3 WT and KO



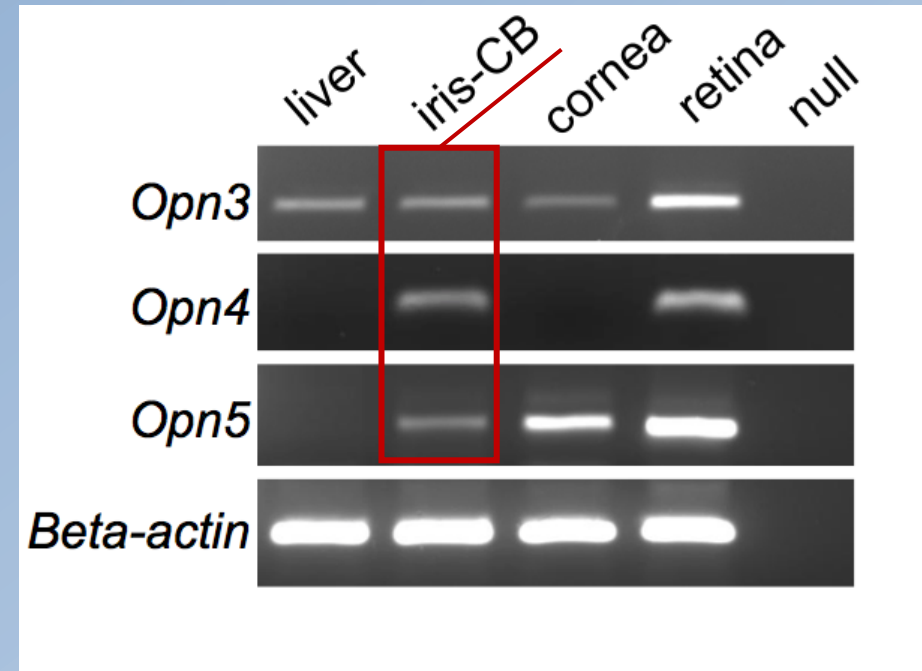
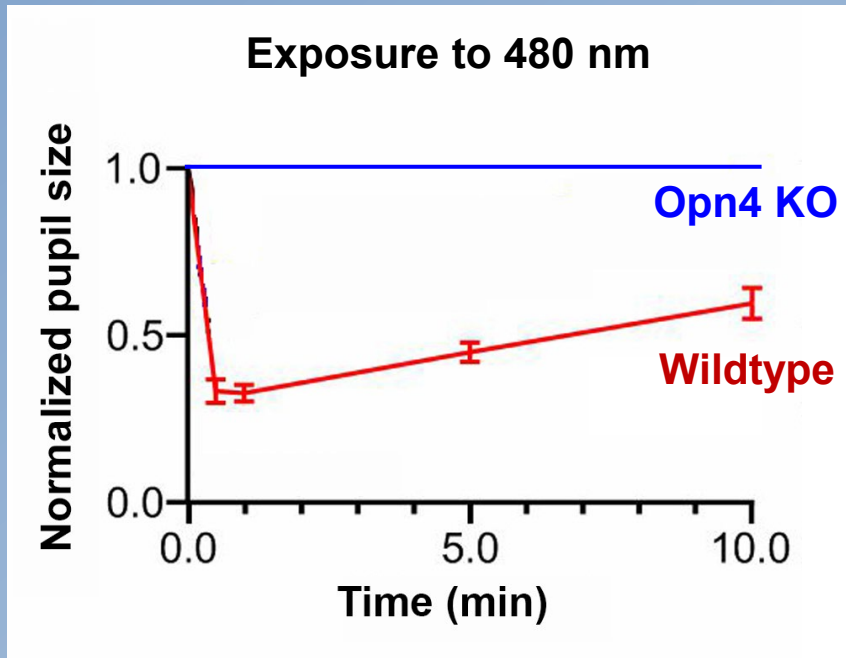
- Hidden food test. Preliminary data.



Mechanisms regulating the local pupillary light reflex (PLR) of the iris



Defining opsin related downstream mechanisms regulating local pupillary light reflex

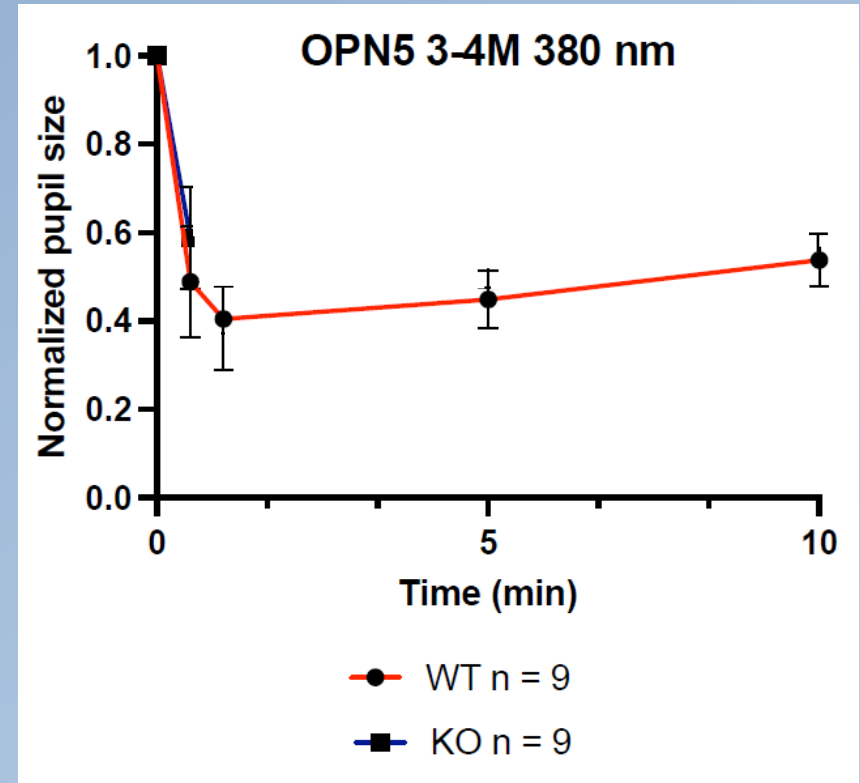
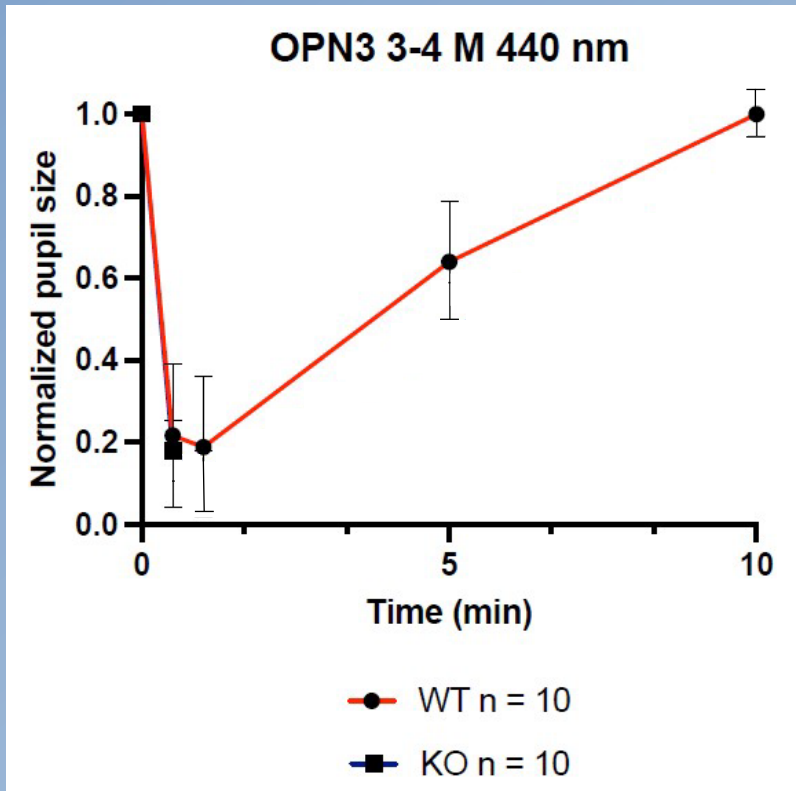


Sghari, Davies, Gunhaga, 2020, IOVS

Tsuchiya et al., 2017, PLoS ONE

- Local photoreceptors Opn3, 4 and 5 are expressed in the iris

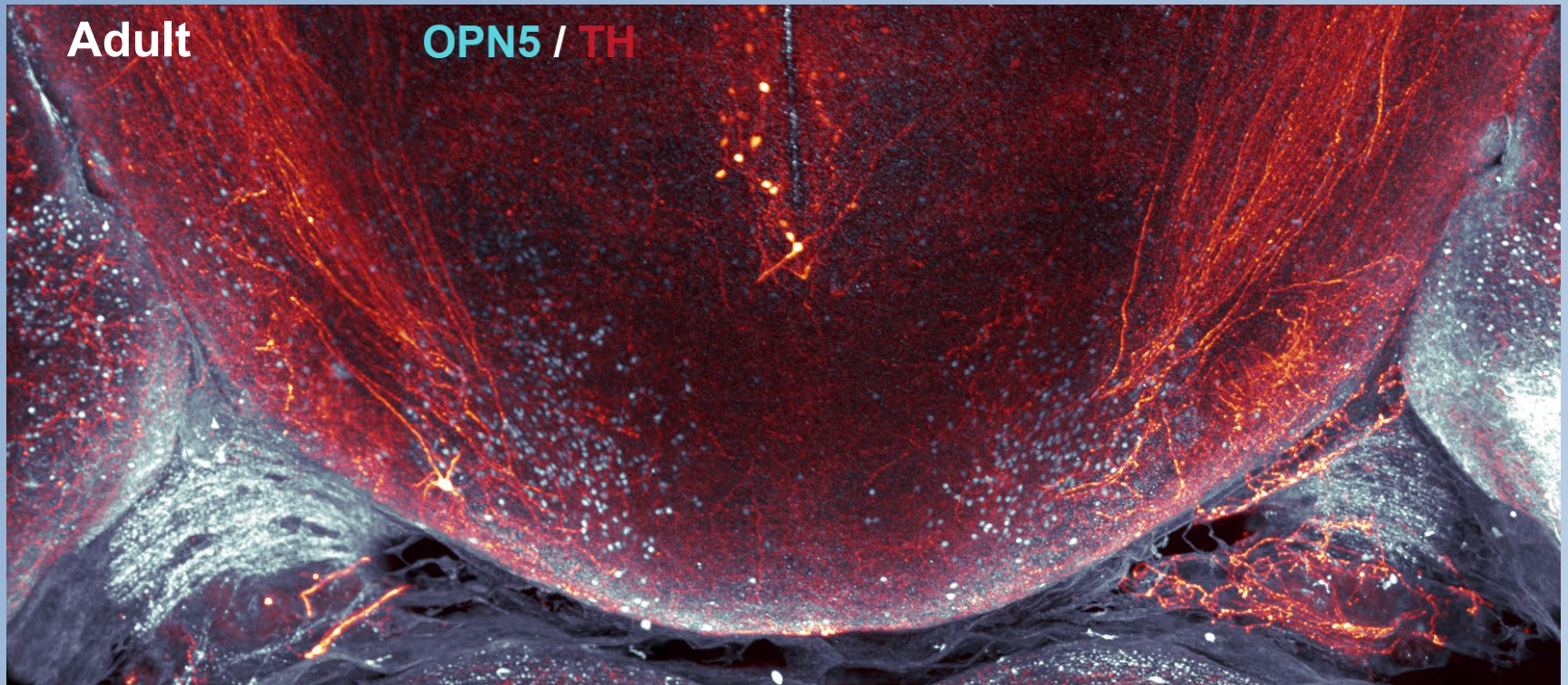
The pupillary light reflex is affected in both OPN3 KOs and OPN5 KOs



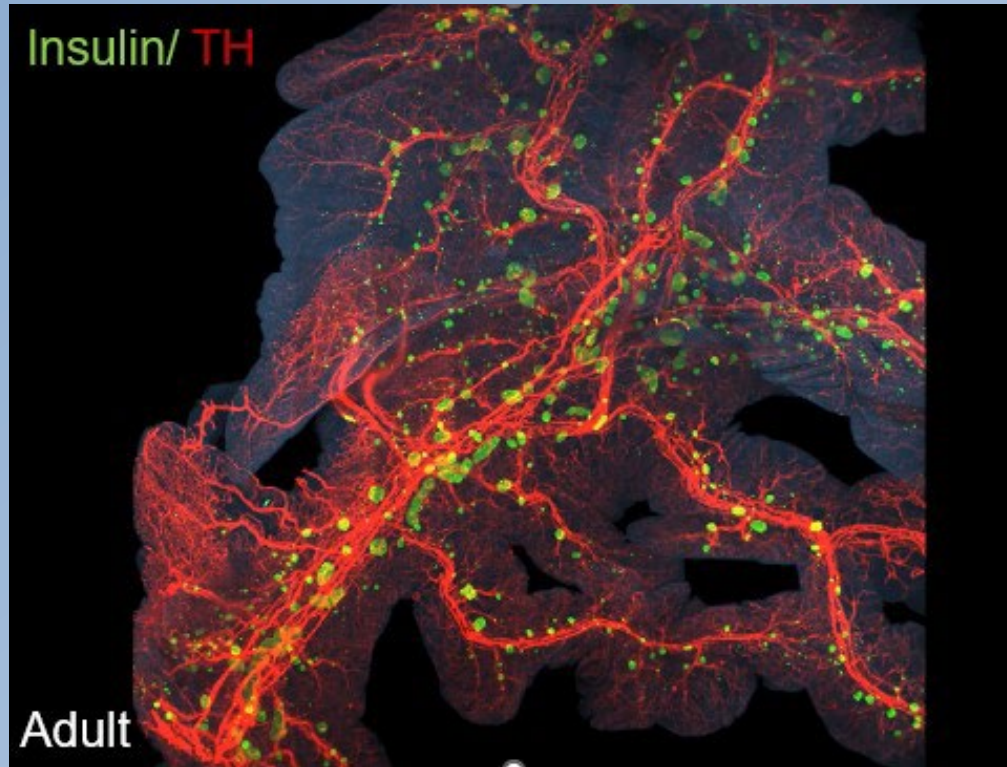
➤ Indicates that OPN3 and OPN5 finetune the sustained pupil contraction and redilation

- Note: KO results not shown here due to unpublished data

Opsin 5 and tyrosine hydroxylase 3D expression in the hypothalamus



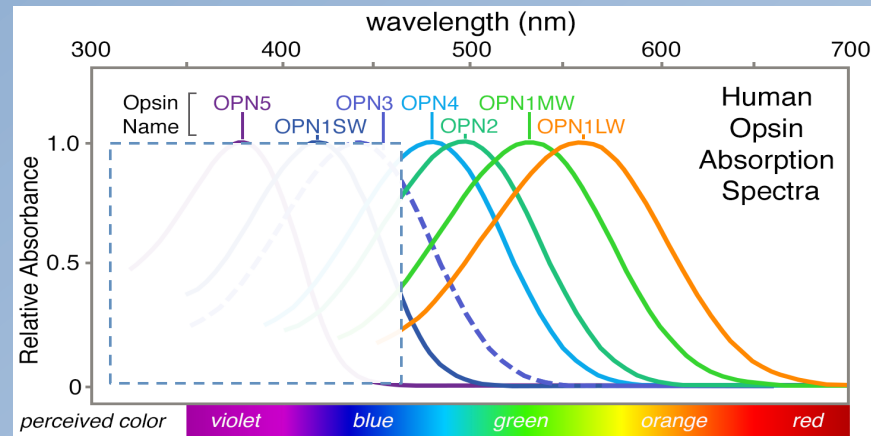
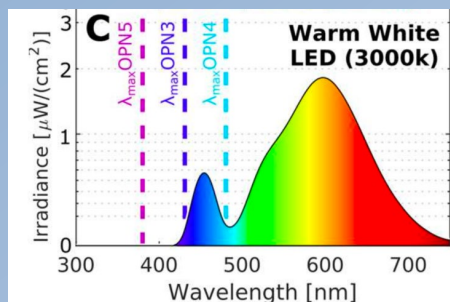
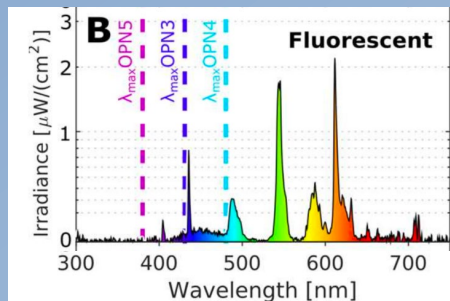
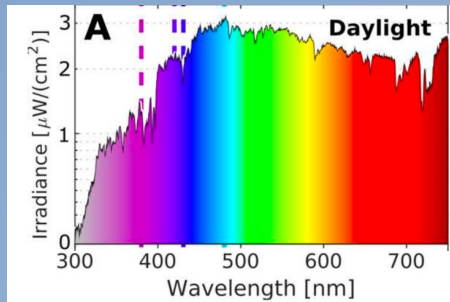
OPN5 KO develop pre-diabetes, but that is not caused by altered TH neural innervations or insulin volume in the pancreas



**3D Light Sheet Fluorescence Microscopy
of the splenic lobe of the pancreas**

- Note: raw data and statistics not shown here due to unpublished data

Daylight includes more UVA, violet and blue wavelengths compared to standard indoor lightning

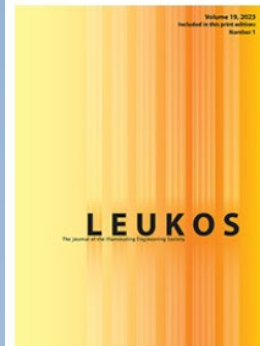
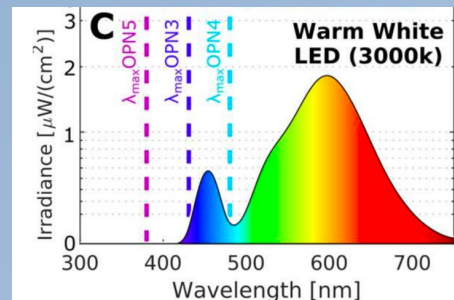
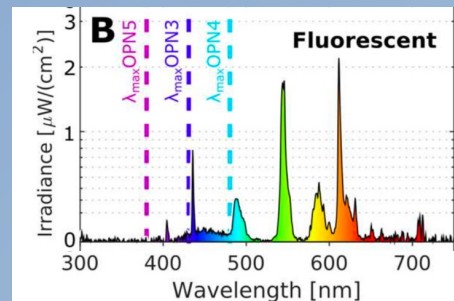
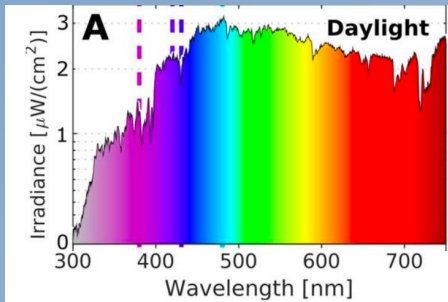


Less time in sunlight leads to increased health issues, for example:

- overeating, obesity and diabetes
- neurodegenerative diseases
- mental health disorders
- myopia

Daylight includes more UVA, violet and blue wavelengths compared to standard indoor lighting

A need to design new spectral tunable indoor lighting systems



LEUKOS

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Buildings, Lighting, and the Myopia Epidemic

Kevin W. Houser, Lisa Hescong & Richard Lang

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Umeå University, Sweden

Present lab members:

Dr. Karthikeyan Ramanujam
Dr. Anna-Carin Hägglund
Dr. Erika Rasmuson
Emanuel Holm

Former lab members:

Dr. Wayne Davies
Dr. Özge Deliktas
Dr. Soufien Sghari
Ariadna Pascau

Collaborations:

Richard Lang	Cincinnati, USA
Ulf Ahlgren	Umeå, Sweden
Ethan Buhr	Seattle, USA
Berit Byström	Umeå, Sweden
Magnus Domellöf	Umeå, Sweden
Gauti Johannesson	Umeå, Sweden

