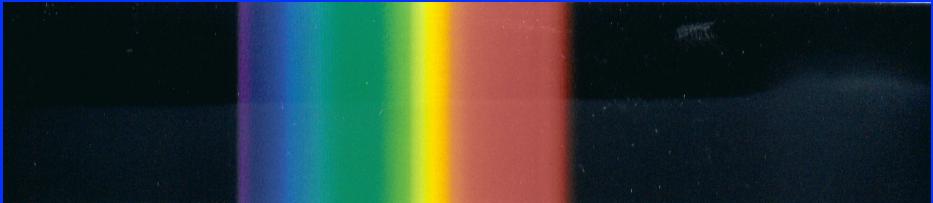
**Effects of Specific Mavelengths of Ambient** Light on Human Blood Chemistry in Alzheimer's and ADHD Subjects

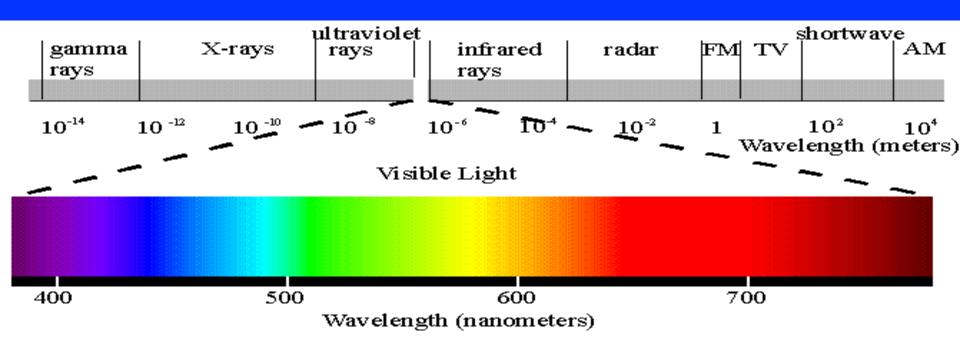
### **ELECTROMAGNETIC SPECTRUM**



4.0.0	UV-C	UV-B	- · · · ·	VISIBLE STIMULI			NEAR IR			
100		280-315 400 (10° OBSERVER: 38				60)	(IR-A: 700 - 1,400) ABOVE VALUES ARE IN NANOMETERS			
	200	300	400	5 <mark>0</mark> 0	6 <mark>0</mark> 0	700	800	900	1000	1100
				WAVEL	ENGTH II	N NANON	/IETERS			

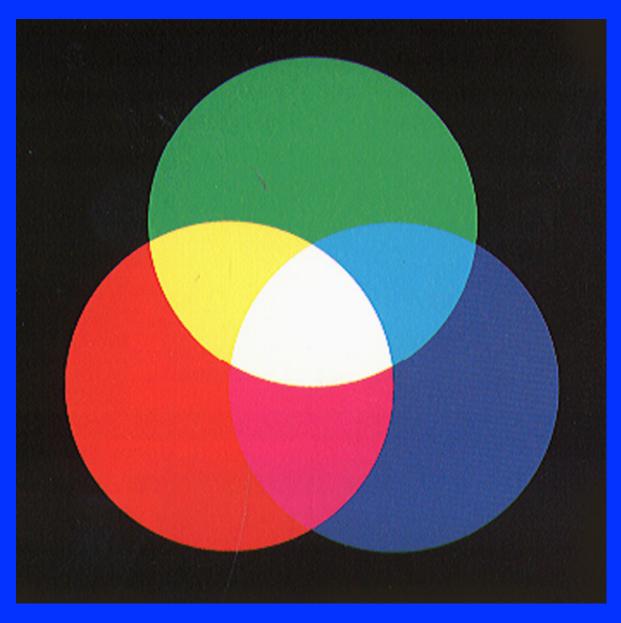
- Light = visible part of the electromagnetic spectrum (380-750). Light is invisible 'till it hits something.
- Measured in wavelengths
- Nanometers (nm) 1 billionth of a meter
- Human range = 780 nm 380nm

## Visible Electromagnetic Spectrum



- Blue = 440 nm
- Green = 500nm

- Yellow = 580 nm
- Red = 680 nm

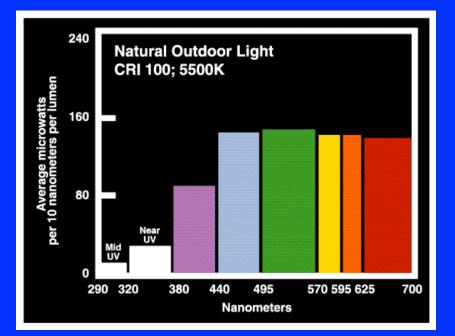


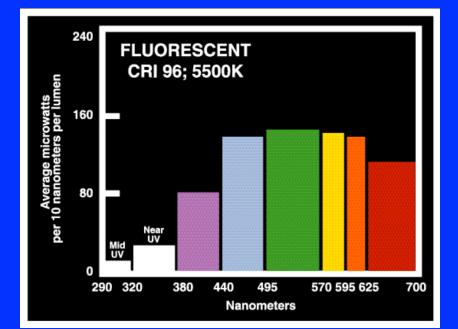
 Combo of all visible nm's in = distrib. = white light

• 5500 K

• 100 CRI (90+)

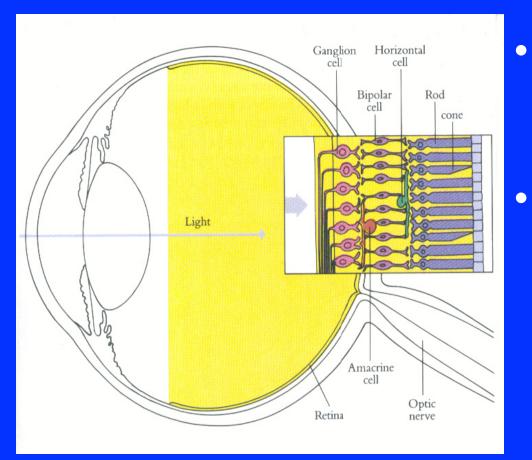
## SPECTRAL DISTRIBUTION CHART

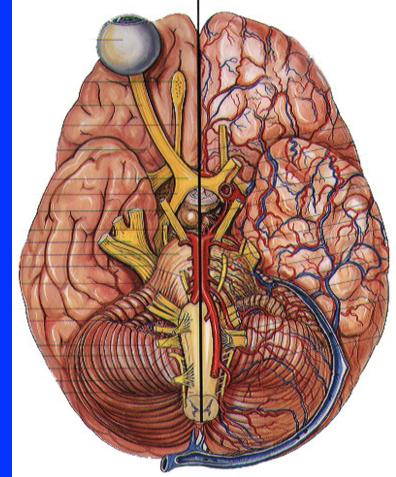




### **Natural daylight**

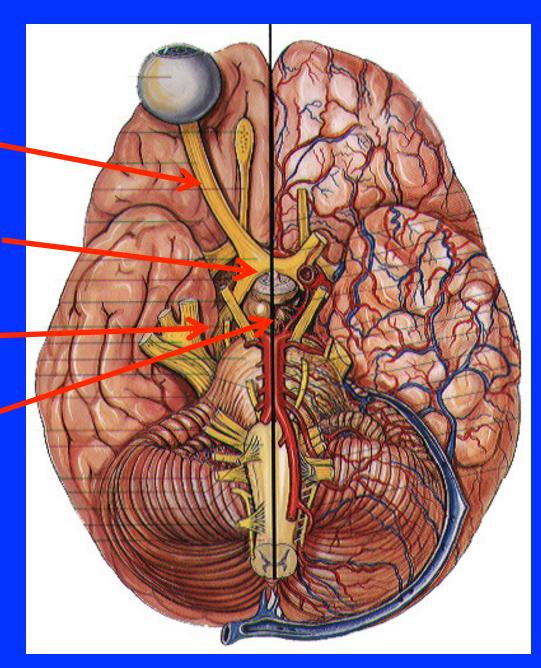
### **Fluorescent light**



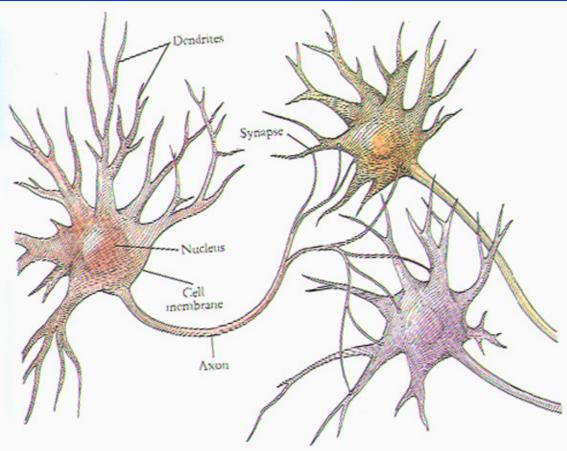


- Optic Nerve carries stimulus to inner brain
- Eyes are part of the brain

- Optic nerve
- Optic chiasma
- Hypothalmus
- Pineal

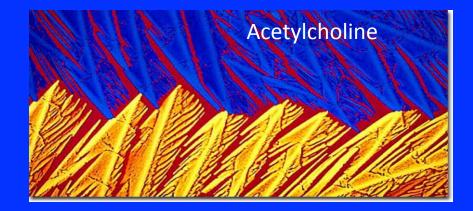


## Neurons

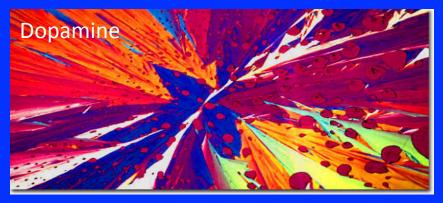


 Particular light triggers production of neurotransmitters/enzymes hormones in brain that influence behaviors Physiological Process

- Influences production of neurotransmitters in brain that:
- Affect mood disorders in adults, adolescents, & children
- Affect agitated behaviors of dementia & ADHD







 Serotonin – all of us – memory, learning, mood enhancer – regulates anger
& aggression, anxiety disorders, depression, obsessive-compulsive, Alzheimer's – excessive levels=toxic

 Dopamine - ADHD, hyperactive adults, bi-polar, social anxiety, regulates pain (fibromyalgia, PKD) – too much = psychosis & schizophrenia

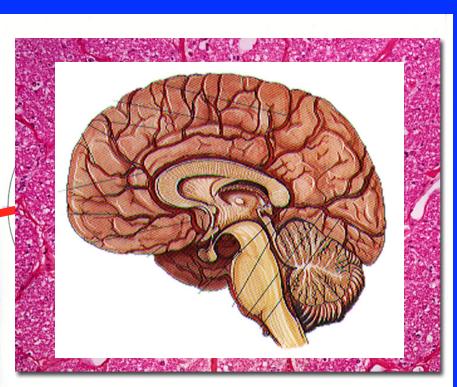
- Norepinephrine ADHD increases alertness, arousal, reward system
- Acetycholine Alzheimer's memory & learning +

## **Seminal Discoveries - 1**

 Photopigment receptor in eye directly responsible for reacting to light & influencing biological effects of light – has nothing to do with vision

(Brainard-Neurology, Tom Jefferson Univ, Phil.PA)

### Ganglion Cells J Biol Rhythms 2005; 20:314



## **Optic Radiations**

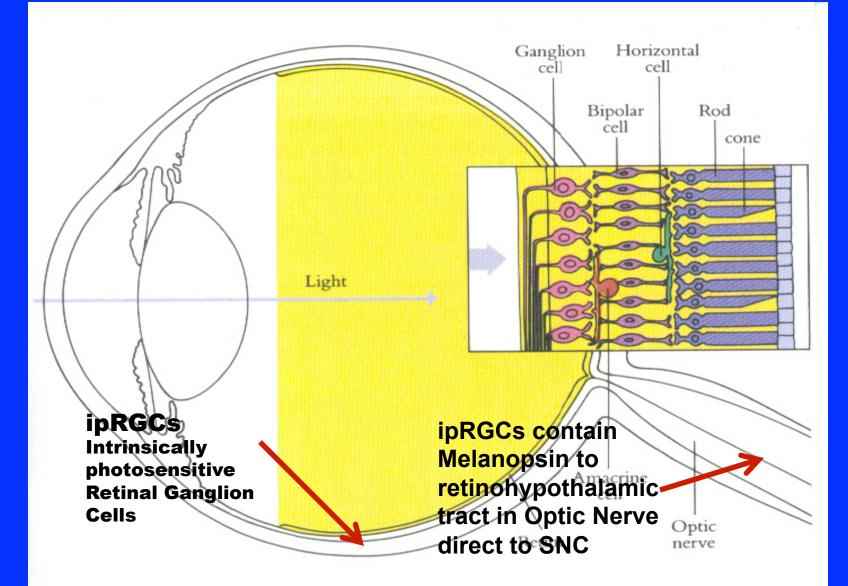
Hypothalmus

Pineal Gland ---

### SCN Suprachiasmatic Nucleus ipRG

ipRGCs to Optic Nerve To SCN direct to Pineal = Sparks neurotransmitter, hormone & enzyme production that control moods, behaviors, +

## **RETINA CELLS**



## **ipRGCs**

- Light sensitive
- Not used for vision
- Direct link to serotonin, melatonin, + other hormones
- Primarily sensitive to blue light
- location suggests blue light in sky above normal field of view
- Regulate through seasonal variations
- Location of the pre-historic Pineal Gland

**Spectral Transmission of Eyelid** Lighting Research Center - Rensselaer

- Eyelid thickness varies thinner at mid to top
- Where more blue light enters & falls on lower **back portion** of retina - The ipRGCs directly to SCN

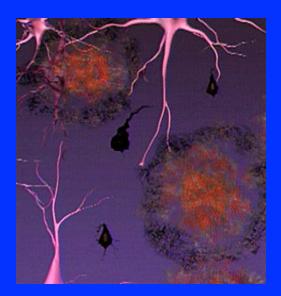
**LRC Sleep Light Treatment Glasses** (Mariana Figueiro, et al) research & prototype '09, production '11

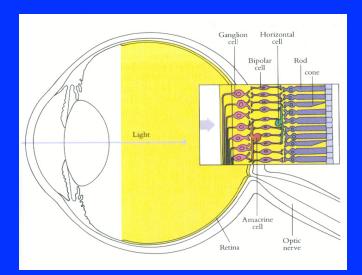
- Blue light positioned high direct to ipRGC's ~~ SCN
- Elderly, Alzheimer's w/agerelated retinal loss – provides stronger signal
- shift workers, spaces w/ limited daylight
- blue light peak at 470nm
- 2 It. levels 50lux & 10 lux
- 50 lux more quickly, higher level & lasted longer



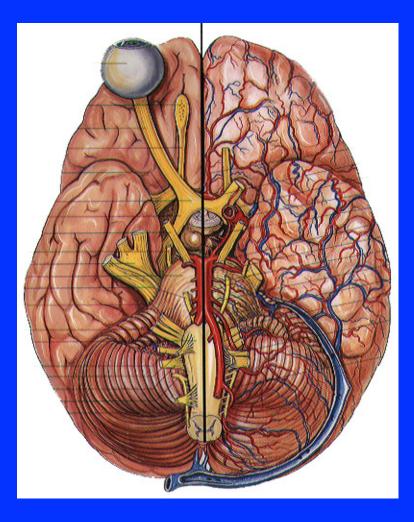
### **Seminal Discoveries – 2**

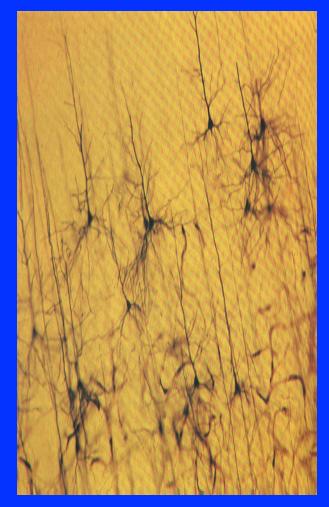
 Eye Laser scans as early detector of Alzheimer's disease - 100% accurate - since '05 experimental test w/humans -





Attempts to find beta amyloid outside the brain have been unsuccessful.





Amyloid plaques – protein deficiency

Proteins generate light & stimulated by light



### **Alzheimer's Neurons & Plaques**

Fluorescent Ligand Scanning

Melanocortin Receptor (MC4R) in eye & directly to hypothalmus can *reverse* memory impairment caused by fibrous amyloyd protein plague build up.

Amyloid protein stimulated by light - particularly blue light.

Blue light triggers the MC4R receptor in eye & hypothalmus & keeps protein energized to *not* form amyloid plaques.

Newest research indicates memory impairment can be reversed. MC4R is now being synthesized for testing hopeful pharmacological use



### Discovered beta amyloid in lens of AD patients

Unusual cataract – no vision intererence; not age-related type; at edges of lens

**Scan - appear** white i patients Laser scan is non-invasive, brief, simple, entirely safe Will eventually be done in ophthalmologists office

video



# To Confirm – biochemical testing

- Eye drops bind to amyloid molecules and
- Light up ! (fluoresce)
- Amyloid acculmulates in lens long before build up in brain
- Now, developing techniques to detect process even before cataracts can be detected
- Should detect decades before symptoms occur

 Goldstein – "Hope to have it available to doctors within the next 2 years." Neuroptix Corp. – Sapphire platform

 Lee E. Goldstein – Harvard Medical School & Brigham & Womens' Hospital – Boston

• The Lancet, April 12, 2003

 On-going research w/humans – Optical Society of America, October 2005

### **Seminal Discoveries – 3**

- Direct monitoring of blood chemistry changes during different daylight exposures
- Jugular vein samples 101 healthy men – assess relation of serotonin to various daylight exposures
- Production of serotonin by brain directly related to duration & intensity of daylight
- Production rose rapidly w/increased light intensity

## **Seminal Discoveries – 3**

 Findings support theory that changes in daylight exposure underlie (at least in part) serotonin release by brain that, in turn, underlie human behavior modifications

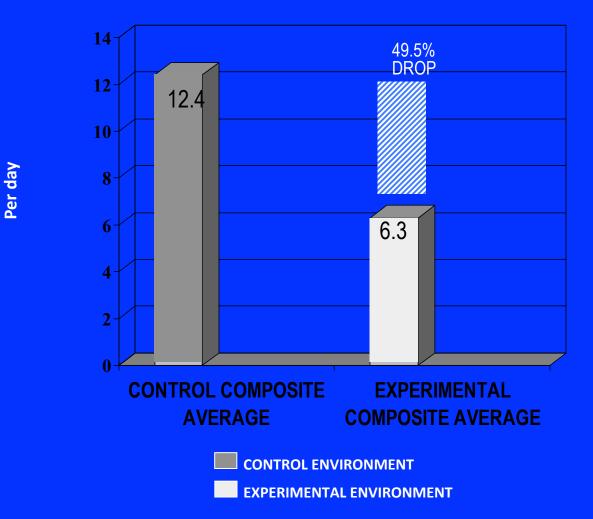
- Human Neurotransmitter Laboratory, Baker Heart Research Institute, Melbourne, Australia
- The Lancet 2002; 360:1840-1842

### **Environmental Light**

- Frequency (nm)
- Duration
- Intensity

 Directly changes brain's blood chemistry that directly affects human behavior, health, performance Manipulating daylight and white electric light

## % OF CHANGE IN DISRUPTIVE BEHAVIORS



**DISRUPTIVE BEHAVIORS** 

Average number of

## **Light Therapy**

Manipulating specific nm's with no daylight for therapeutic purposes

- Blue 440 nm
- Green 500 nm
- Yellow 580 nm
- **Red** 680 nm
- White 91 CRI 5550 K

- Normal healthy middle aged subjects
- Normal healthy elderly subjects
- Alzheimer's subjects
- ADHD adolescent subjects
- Non-ADHD adolescent subjects

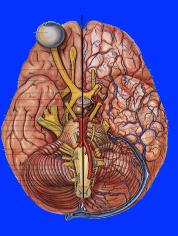
How do observed behaviors compare to changes in blood chemistry?

### Light Induced Changes in <u>ADHD</u> Behaviors & Blood Chemistry

### **Positive**

White normal adolescent behavior

Yellow limited animation in control



### **Negative**

Red intensely hyperactive & defiant

Green very pronounced hyperactivity & defiance w/no

self-control

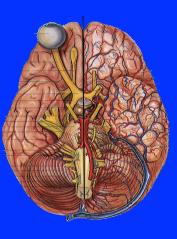
**Blue** most passive

Blood chemistry analysis (statistical analysis of radio-immunological assays) corroborates behavior observations

### Light Induced Changes in Alzheimer's Behaviors & Blood Chemistry

#### **Positive**

### White most positive



### <u>Negative</u>

#### Red intensely disruptive & confused

**Blue** most passive

Yellow high % of negative behaviors

#### Green moderately positive

Blood chemistry analysis corroborates behavior observations

## **Normal Healthy**

 Red – agitated, stressed, warm, poor visual acuity

- Green passive, at rest, calm
- Blue calm, passive, at rest
- Yellow energetic, happy, at work
- White highly energetic, at work, calm





## Schizophrenia & Insomnia



### **BLUE LIGHT HAZARD**

World Health Org declared blue light a carcinogenic - 2007 –

(breast and prostate cancer studies)

- Conclusive research findings still out
- At risk those w/macular degeneration & retinal eye problems
- Industry setes standards for bright light and UV radiation but none for blue light hazard

## **Common Threads**

- White daylight not yellowed, best, highest energy level
- White electric light approx. 5500k, 90+ CRI, good substitute for daylight
- Blue no harm, restful to all, selective use
- Yellow selective use, good for hyper people, NO for dementias, bipolar disorders
- Green NO for hyperactive people, good for normal healthy

Daylight - behavior & performance studies

 Office worker performance – daylight w/view – 6%-12% faster – 10%-25% better mental function and memory

 Schools – those w/most daylt. – 20% faster on math, 26% faster on reading – 21% higher student learning rates overall than those w/least daylight

## Recommended Daylight Factors



DF

• Ordinary seeing tasks (reading, easy office work) 1.5-2.5%

- Moderately difficult tasks 2.5-4.0% (normal machine work, prolonged reading)
- Difficult, prolonged tasks 4.0-8.0% (drafting, proofreading, fine machine work)

 Retail Stores – max. effect = 40% increase in sales, energy savings = \$. 24/sf & \$.66/sf w/optimized daylight

profit from increased sales = 19 x's energy savings & 45-100 x's energy savings w/optimized daylight system

Source for offices, schools, retail: Heschong Mahone Group Dr. Brainard – "hope the science may lead to a new generation of lights & screens designed with wavelengths that adjust according to the time of day."

NASA now hired Dr. Brainard to do just that

"we're on the verge of a lighting revolution, if the light system can be made to work during spaceflight, "people will use it here on the ground."





### **Very Brief Pubs List**

- Journal of Architecture, Planning & Research
- Intl Congress of Neuropsychiatry, Endocrinology, & Immunology – Bregenz, Austria
- Intl Congress for Global Health Progress -World Health Org & UNESCO – Paris, France
- Experimental Gerontology
- Journal of Interior Design
- Intl Congress of People-Environment Studies Vienna, Austria
- World Congress for Environmental Design for the New Millennium – Seoul, Korea
- Inform Design

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