

# **BIOLOGICAL RHYTHMS:**

## **IT'S A MATTER OF TIME**

- **Examples of Biological Rhythms**
- **Rhythms: Environmental  
Geophysical**
- **Circadian Rhythms: Mechanism  
Melatonin**
- **Some features of the human circadian (24-hr.)  
biological clock**
- **The molecular mechanism of circadian rhythm**
- **Effects of sleep disorders**
- **Video**

# BIOLOGICAL RHYTHMS

**Rhythm** = sequence of events that repeat themselves in the same order and with the same time interval, over and over again.

**Biological rhythm**: a biological event or function with a pattern of activity that is repeated over and over again at a constant time interval.

# What is a Rhythm?

Pattern

Sequence

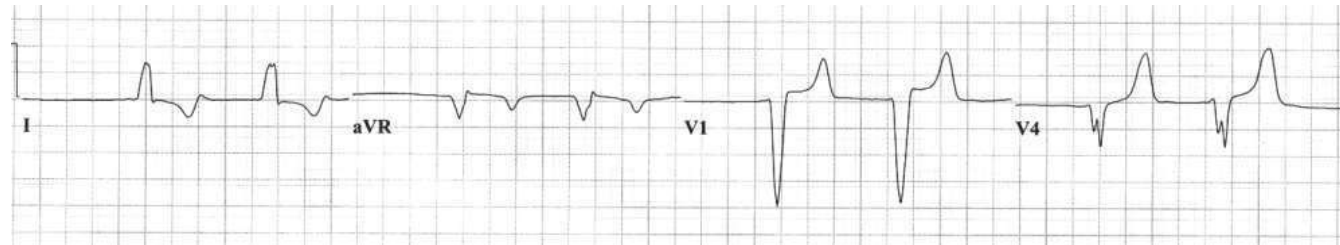
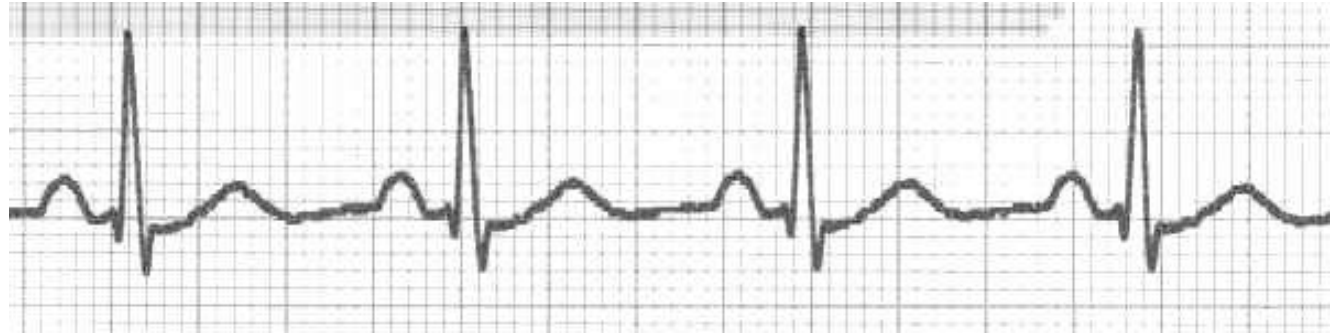
Regularity

Progression

Time

Measure

Beat



# Examples of Biological Rhythms

Heart rate

Breathing

Hormone secretion

Menstrual cycle

Body temperature

Sleep/wake cycle



Time

## Chronobiology

Biological Rhythms are the product of an internal biological timekeeping system which is controlled by a biological clock

# **ENVIRONMENTAL RHYTHMS**

## **Semi-Daily Rhythms**

- Tidal

## **Daily Rhythms**

- Solar

## **Monthly**

- Lunar

## **Quarterly**

- Seasons

## **Annual**

## **Longer than a year**

## Types of biological rhythms with a geophysical counterpart

Period Length	Name	Chronobiological Name	Example
12.4 h	tidal	<b>CIRCA TIDAL</b>	Crab activity on shoreline
29 days	monthly	<b>CIRCA LUNAR</b>	Menstrual cycle, marine reproduction.
365 days	yearly	<b>CIRCANNUAL</b>	Hibernation, many reproductive cycles.
24 h	daily	<b>CIRCADIAN (circa + diem)</b>	Sleep-wake cycle etc.

**"CIRCA DIEM"**  
**OR**  
**"APPROXIMATELY A DAY"**

# Circadian rhythms



Your **circadian rhythm** (also known as your sleep/wake cycle or body clock) is a natural, internal system that's designed to regulate feelings of sleepiness and wakefulness over a 24-hour period.

- Circadian rhythms are endogenous.
- Endogenous rhythms are not exactly 24h.
- The periods of Circadian rhythms are genetically determined.
- Endogenous rhythms are temperature-compensated

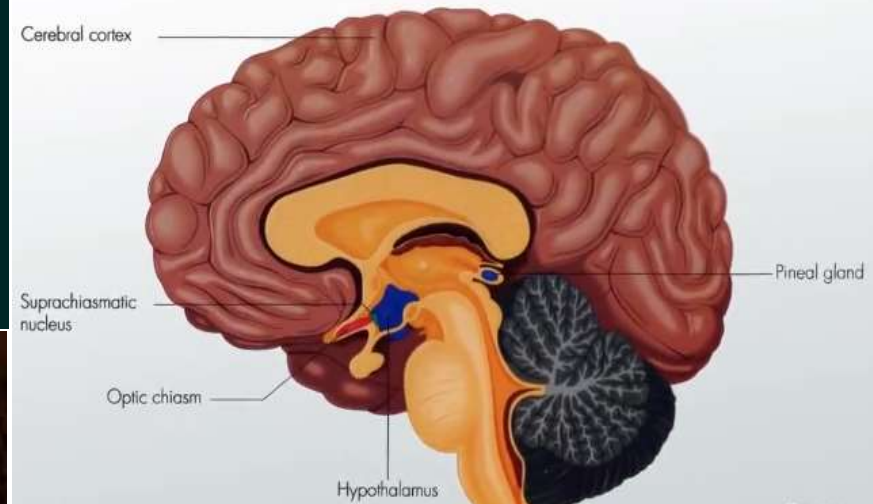
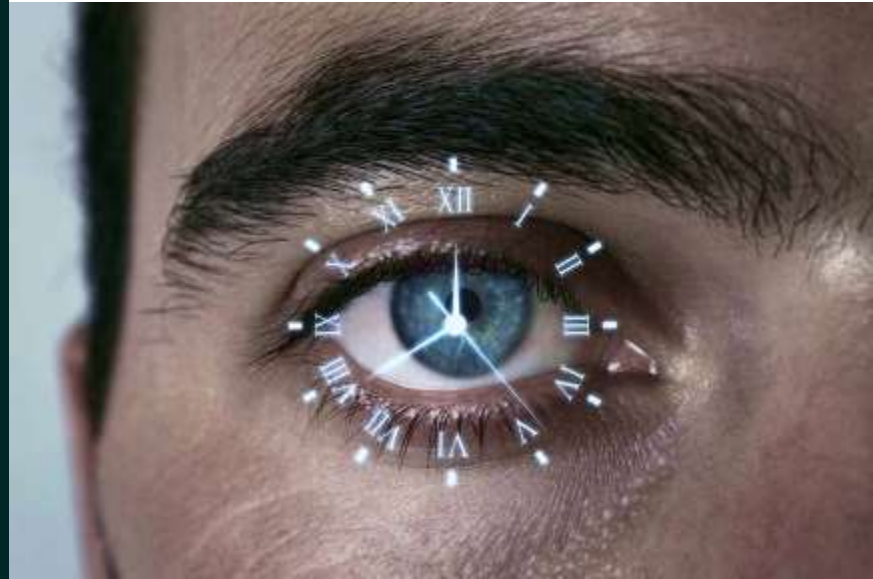
# Circadian rhythms

These 24-hour rhythms are driven by a [circadian clock](#), and they have been widely observed in [plants](#), [animals](#), [fungi](#), and [cyanobacteria](#).

Although circadian rhythms are endogenous ("built-in", self-sustained), they are adjusted (entrained) to the local environment by external cues called [zeitgebers](#) (from German, "time giver"), which include [light, temperature and redox](#) cycles



MANY  
OF OUR  
BODY'S SYSTEMS  
ARE CALIBRATED TO THE  
APPEARANCE AND  
DISAPPEARANCE  
OF THAT NATURAL LIGHT



Light



Output Rhythms:

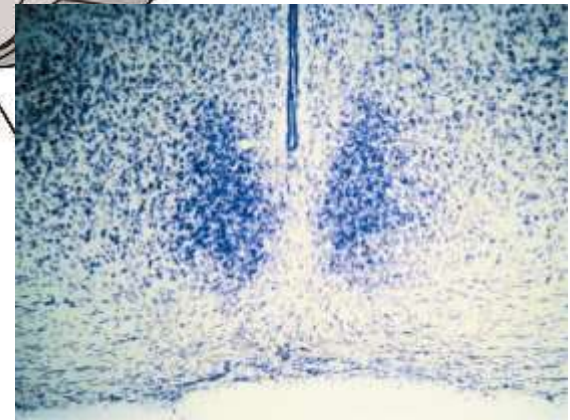
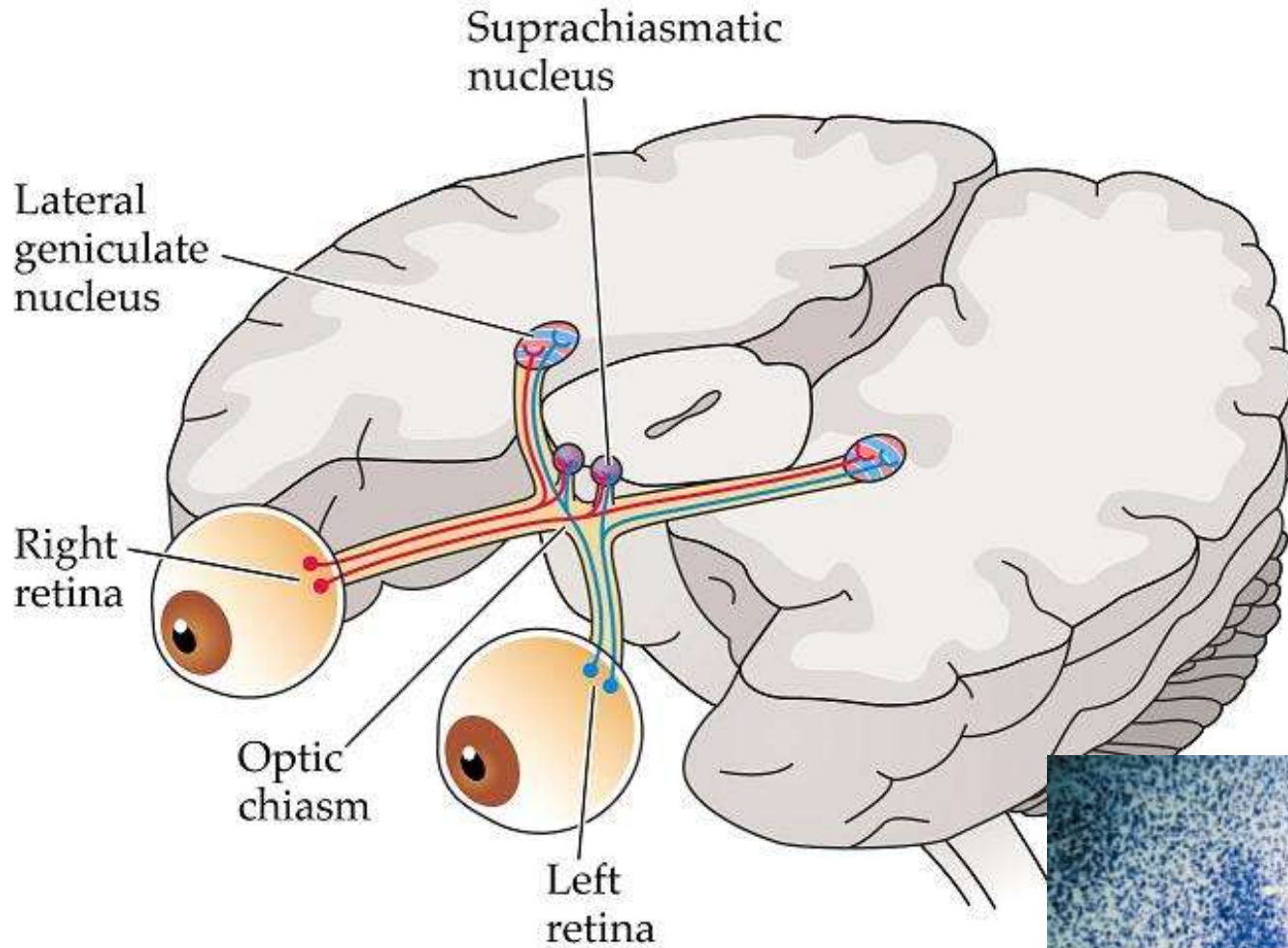
Physiology

Behavior

Suprachiasmatic  
Nucleus (SCN)

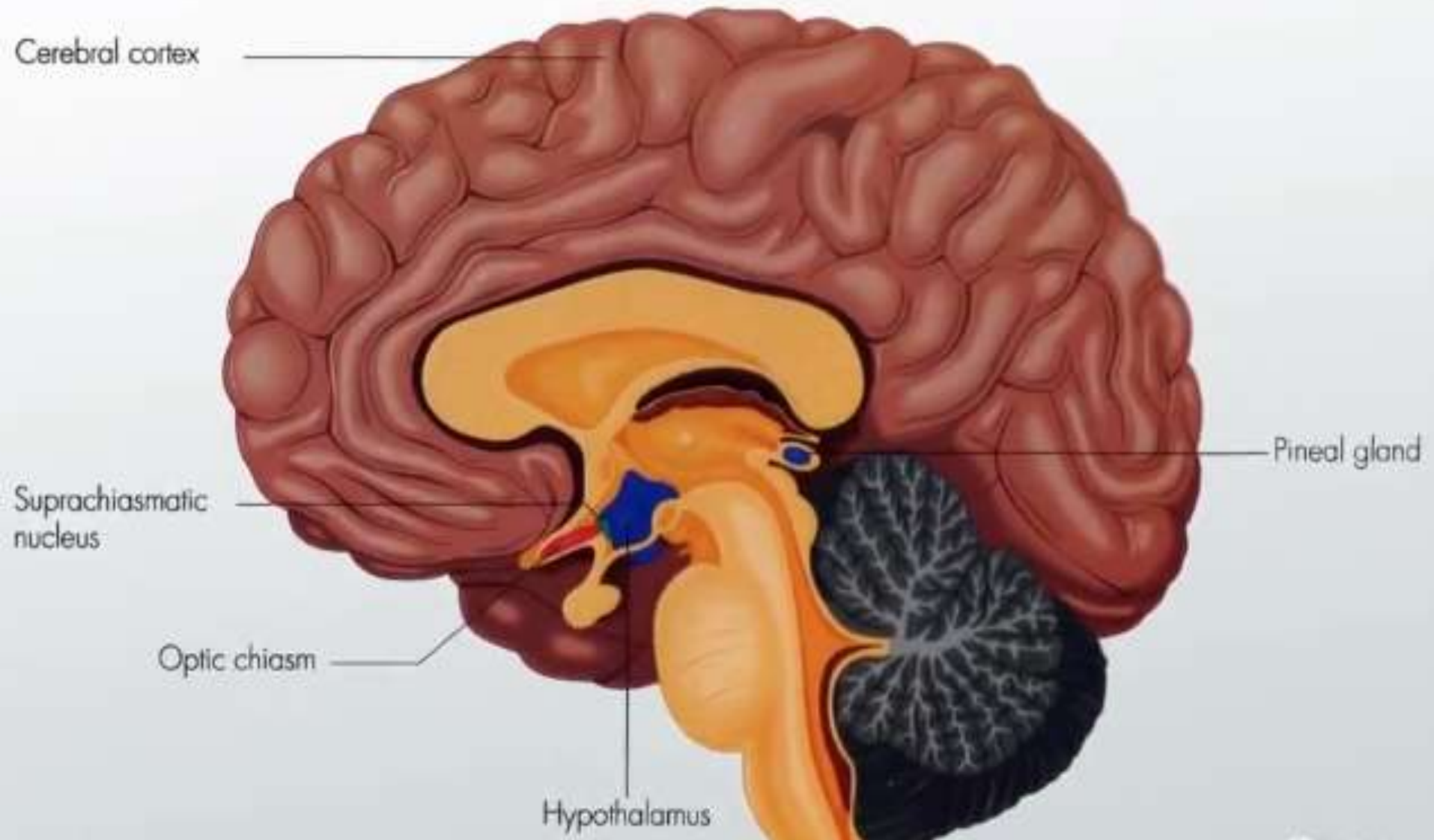



# NEURAL MECHANISMS OF CIRCADIAN RHYTHMS



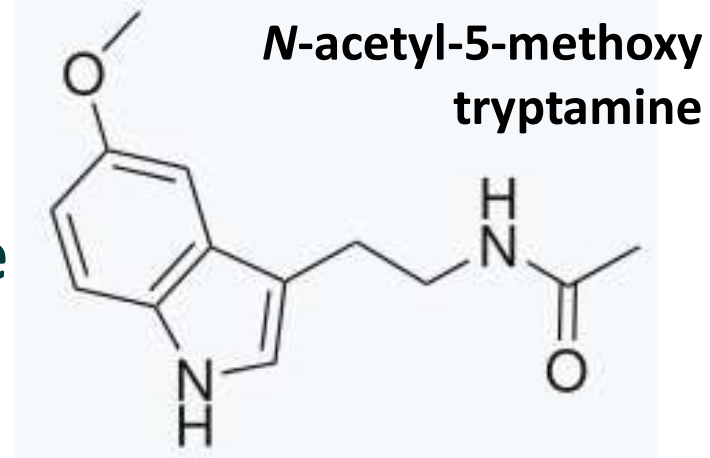


# Our Inner Clock



- 
- **Circadian rhythms** help determine our sleep patterns.
  - The body's master clock, or **Supra Chiasmatic Nucleus (SCN)**: in the hypothalamus of Brain
  - **SCN** controls the production of **melatonin**, a hormone that makes you sleepy – in the pineal body
  - It receives information about incoming **light** from the optic nerves, which relay information from the **eyes to the brain.**

# How the ups and downs of **Melatonin** affect sleep time

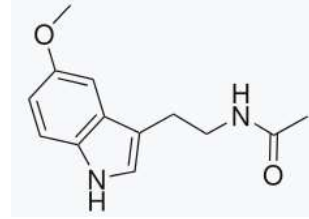


A **hormone** that's made by the pineal gland in the brain, melatonin helps control our daily sleep-wake cycles.

Our [circadian rhythm](#) influences how much melatonin the pineal gland makes, and so does the amount of light that we are exposed to each day.

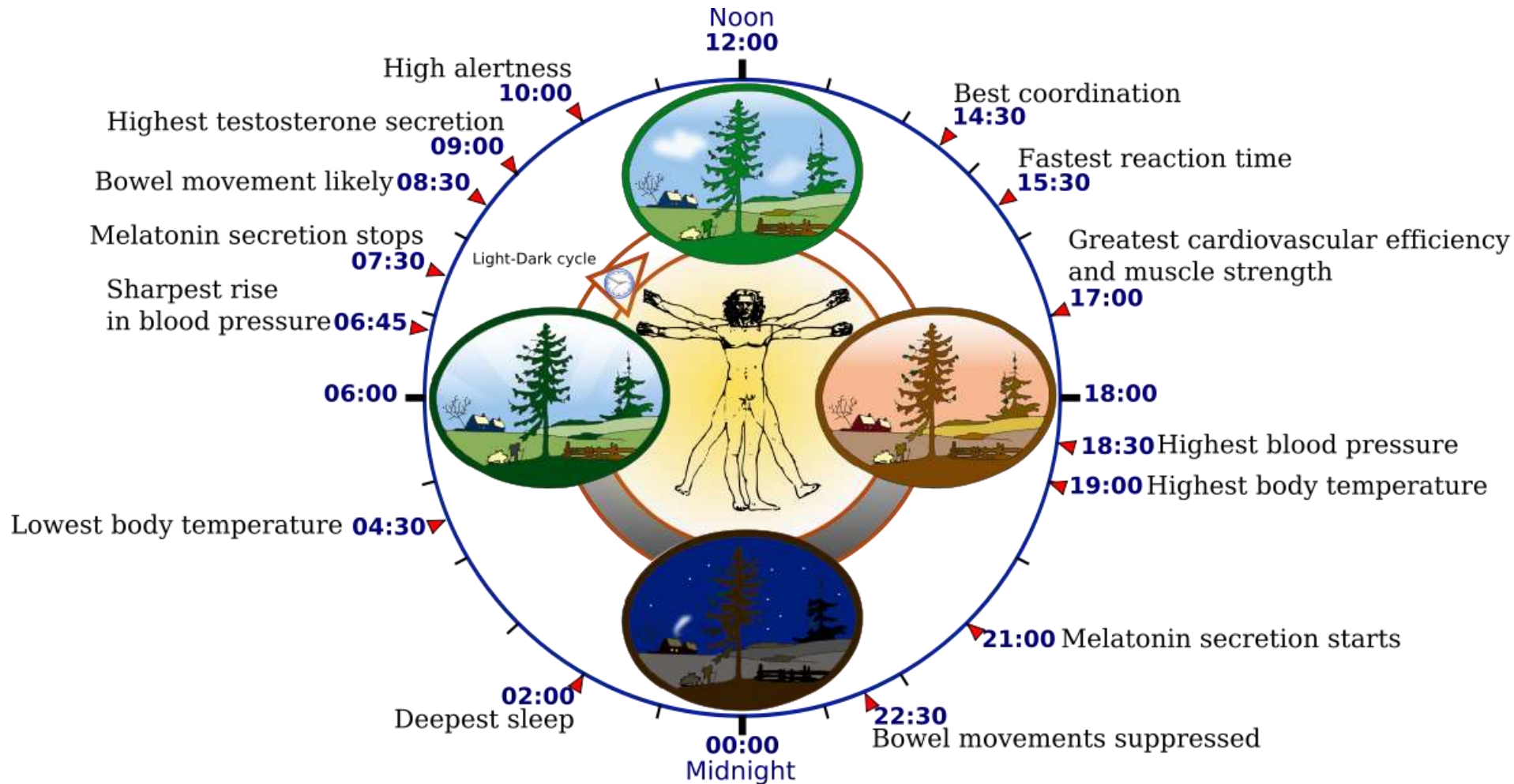
Typically, melatonin levels start to **rise in the mid-to-late evening**, after the sun has set. They **stay elevated for most of the in the dark**. Then, they **drop in the early morning** as the sun rises, causing us to awaken.

# Melatonin



- Foods such as tomatoes, walnuts, olives, rice, barley, strawberries, cherries, and cow's milk contain melatonin. When our body absorbs melatonin from these foods, we **begin to feel calm and sleepy.**
- It is often used by those who suffer **from jet lag, shift-work-related sleep troubles, or insomnia.**
- Melatonin supplements come in **pill, liquid, chewable, or lozenge** forms, in doses ranging from 1-10 mg.

# Some features of the human circadian (24-hr.) biological clock



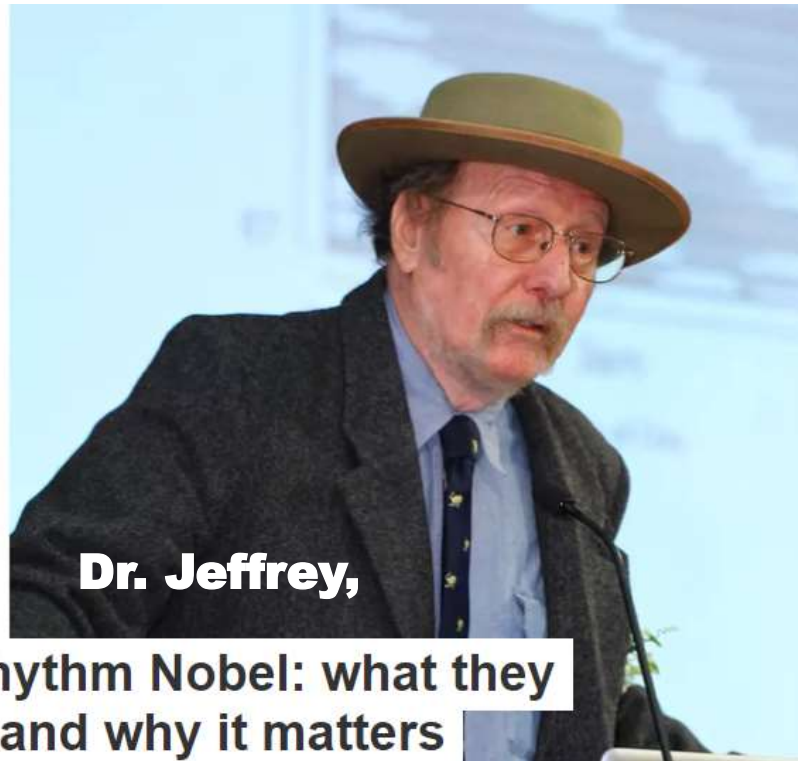


# THE MOLECULAR MECHANISM OF CIRCADIAN RHYTHM

RESEARCH SHOWS  
**Your Genes Affect Your Sleep Clock**

# The NOBEL Prize in Physiology or Medicine

## Oct. 2017



Circadian rhythm Nobel: what they discovered and why it matters

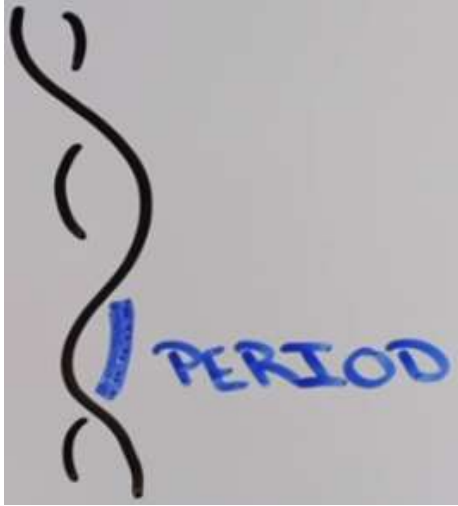
**Dr. Michael Young**

### CLOCK GENES

- **1988** **PERIOD**
- **1994** **TIMELESS**
- **1998** **DOUBLE TIME**



RED-EYED FRUIT FLY



Worked on the gene called **PERIOD** that influenced the circadian rhythm of the fruit-fly

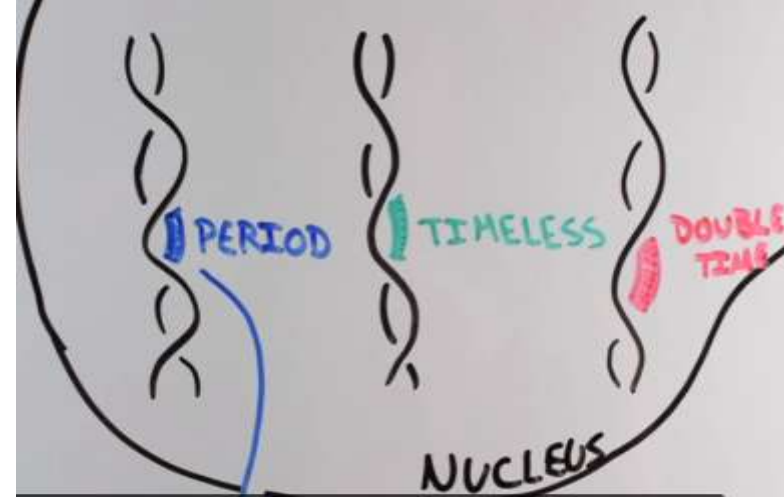
They induced **mutations** that shifted the cycle from 24 to 19 hrs and the other to 29 hrs

The protein was scattered in the nucleus of all cells of the fly and it was more in day than at night (turning on and off mechanism – **switch master**)



Confirmed the presence of **TIMELESS** Gene

The TIMELESS worked with PERIOD and *moved into* the nucleus of cell and *stopped production* of PERIOD – like a security person ('Allow' & 'Stop')



**DOUBLE TIME** Limits the stability of PERIOD so that it does not buildup too quickly

The TIMELESS shuts up and teams up with PERIOD to enter into nucleus and PERIOD shuts down its own production

Once level of PERIOD goes low the whole process starts up again

## THE MOLECULAR MECHANISM OF CIRCADIAN RHYTHM

# THE MOLECULAR MECHANISM OF CIRCADIAN RHYTHM

The **PERIOD** gene starts making the PERIOD PROTEIN –  
Outside the Nucleus of cells

The **DOUBLE TIME** gene limits stability of PERIOD so that it  
does not build up too quickly

The **TIMELESS** gene shows up and  
- transfers PERIOD enter into nucleus &  
- PERIOD shuts up again

**A calm, cool and collected  
24 hour cycle**

From Fruit-fly to Nobel Prize



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# Effects

## of sleep deprivation

# SLEEP STAGES

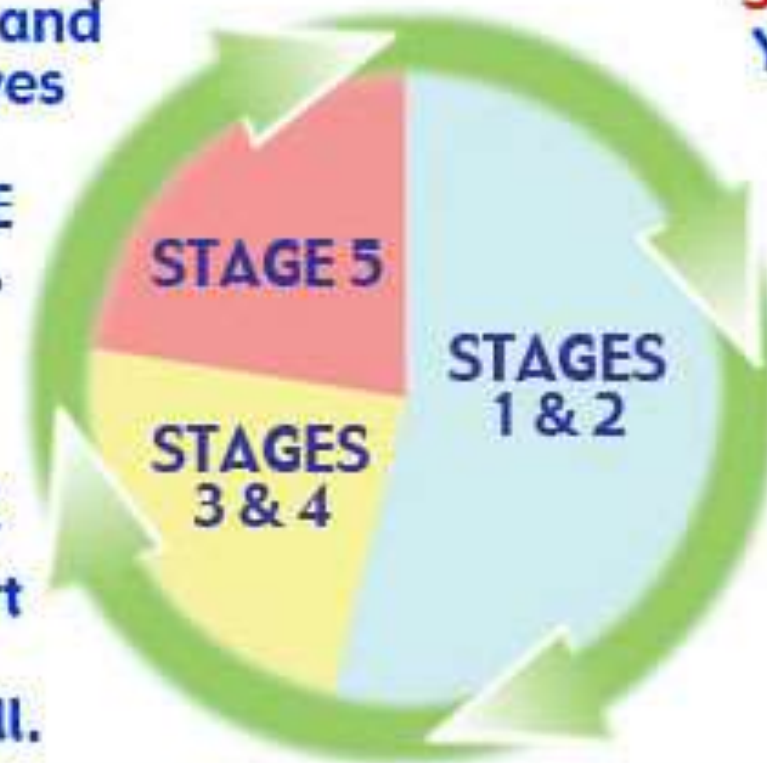
## STAGE 5 $\delta$

Your brain is active and you dream. Your eyes move under your eyelids in RAPID EYE MOVEMENT (R.E.M).

## STAGES 3 & 4

You are in a deep, restful sleep. Your breathing and heart rate slow down, and your body is still.

$K + \delta$



## STAGES 1 & 2

You first fall asleep, but are not yet in a deep sleep.

$\alpha$



# **SLEEP FUNCTIONS: (Why do we sleep?)**

- **Restorative Functions**
  - growth and repair
- **Adaptive Functions**
  - predator avoidance
  - energy conservation
- **Cognitive Functions**
  - learning, unlearning, reorganization



# **Why Can't I Sleep? 6 Surprising Factors:**

## **A Daytime Interactions**

- Women having +interactions with men sleep better at night;
- Men who sleep better will have +interactions in next day.

## **Bed Clothes**

Sleep uniform: Cotton, loose clothes, fresh sock (in winter) induce good sleep

## **Spicy Dinner**

Not conducive because of induction of acid-refluxes; stomach acid backs up, heartburns are bad for sleep

## **Fluffy- Pet allergies**

Dog, cat pets are not friendly to put you to sleep

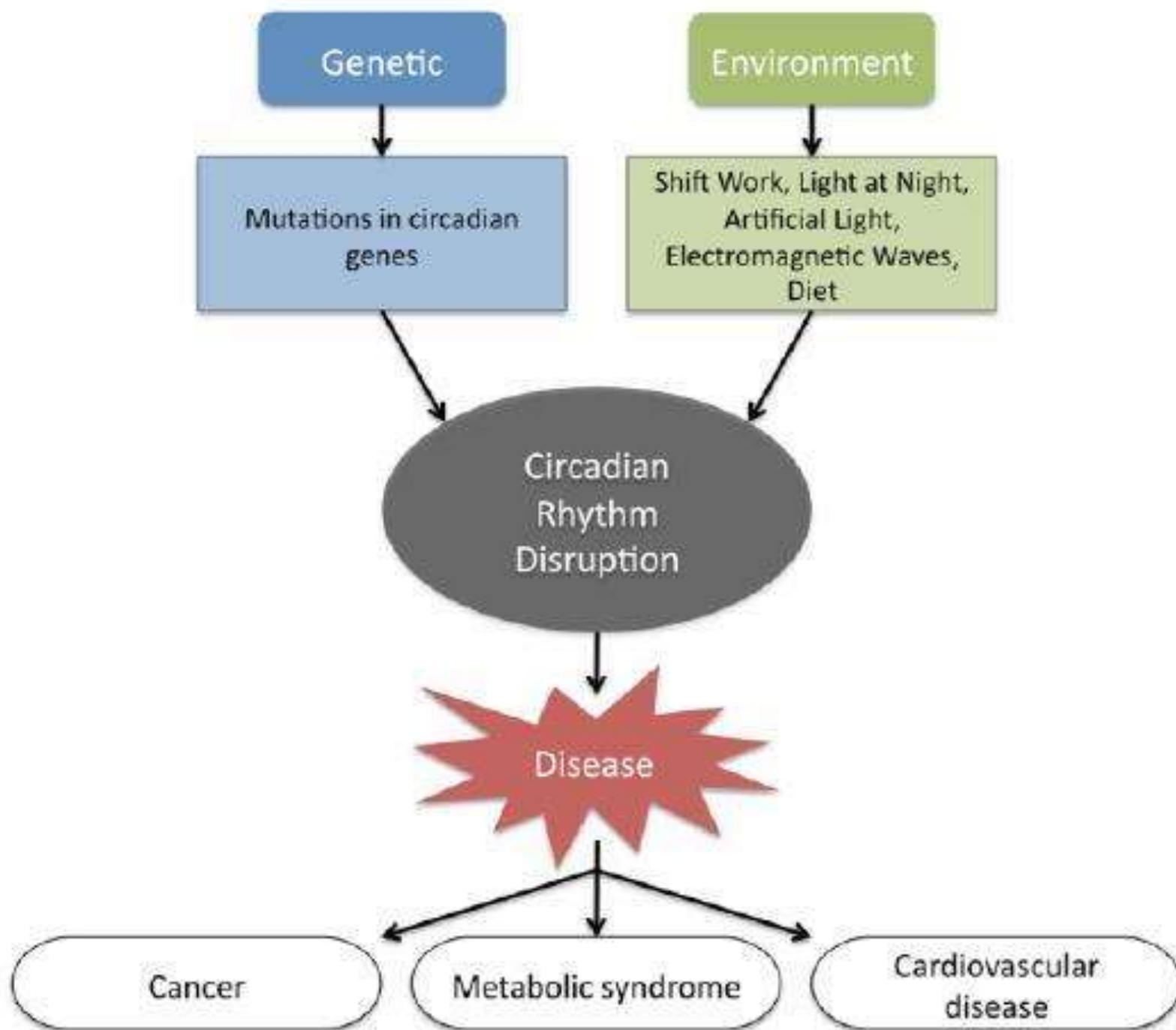
## **Hot shower/coffee/exercise**

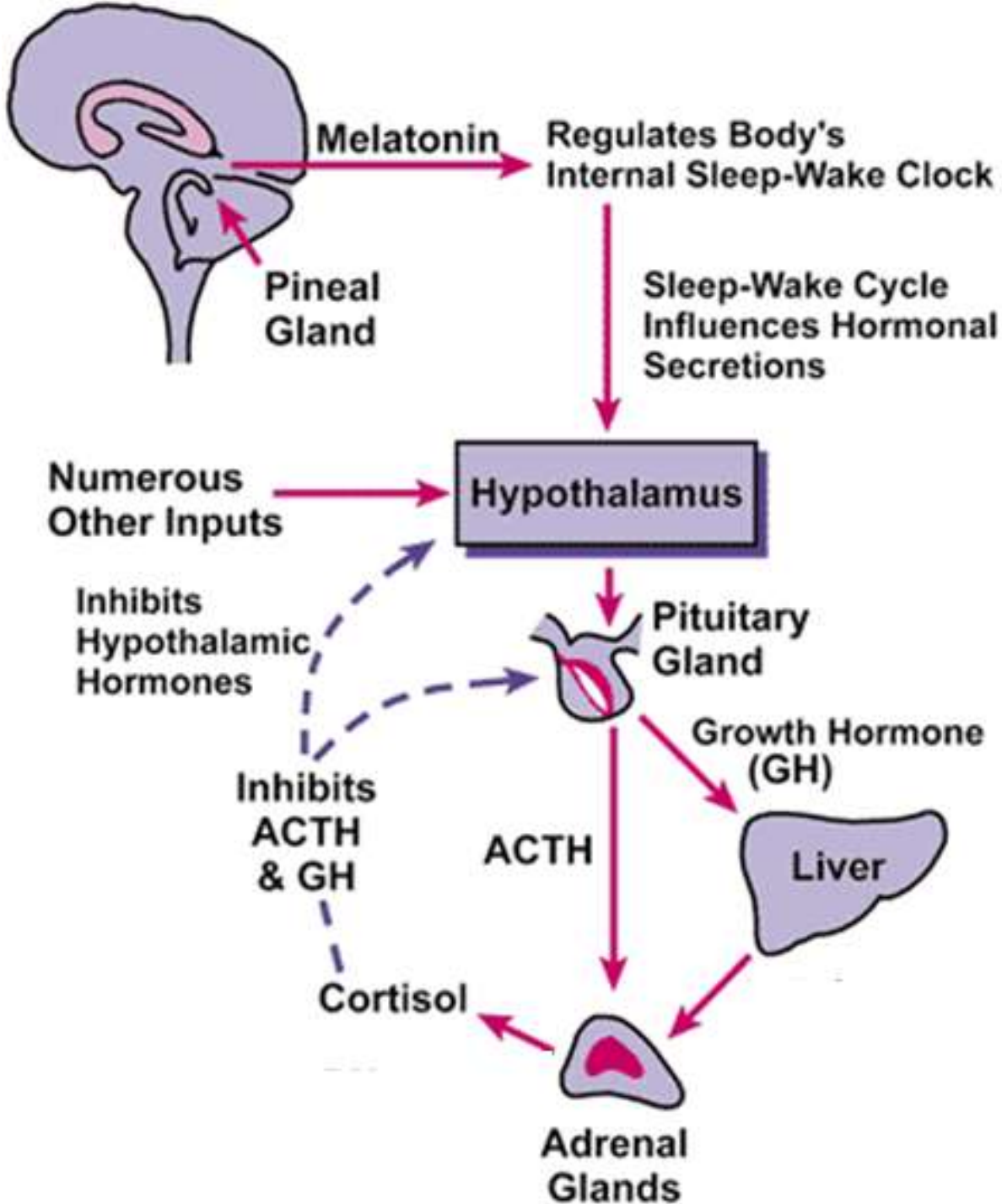
Not good since they keep you awake and alert

## **Cigarette smoke**

Nicotine is a stimulant; Not good since they keep you awake and alert



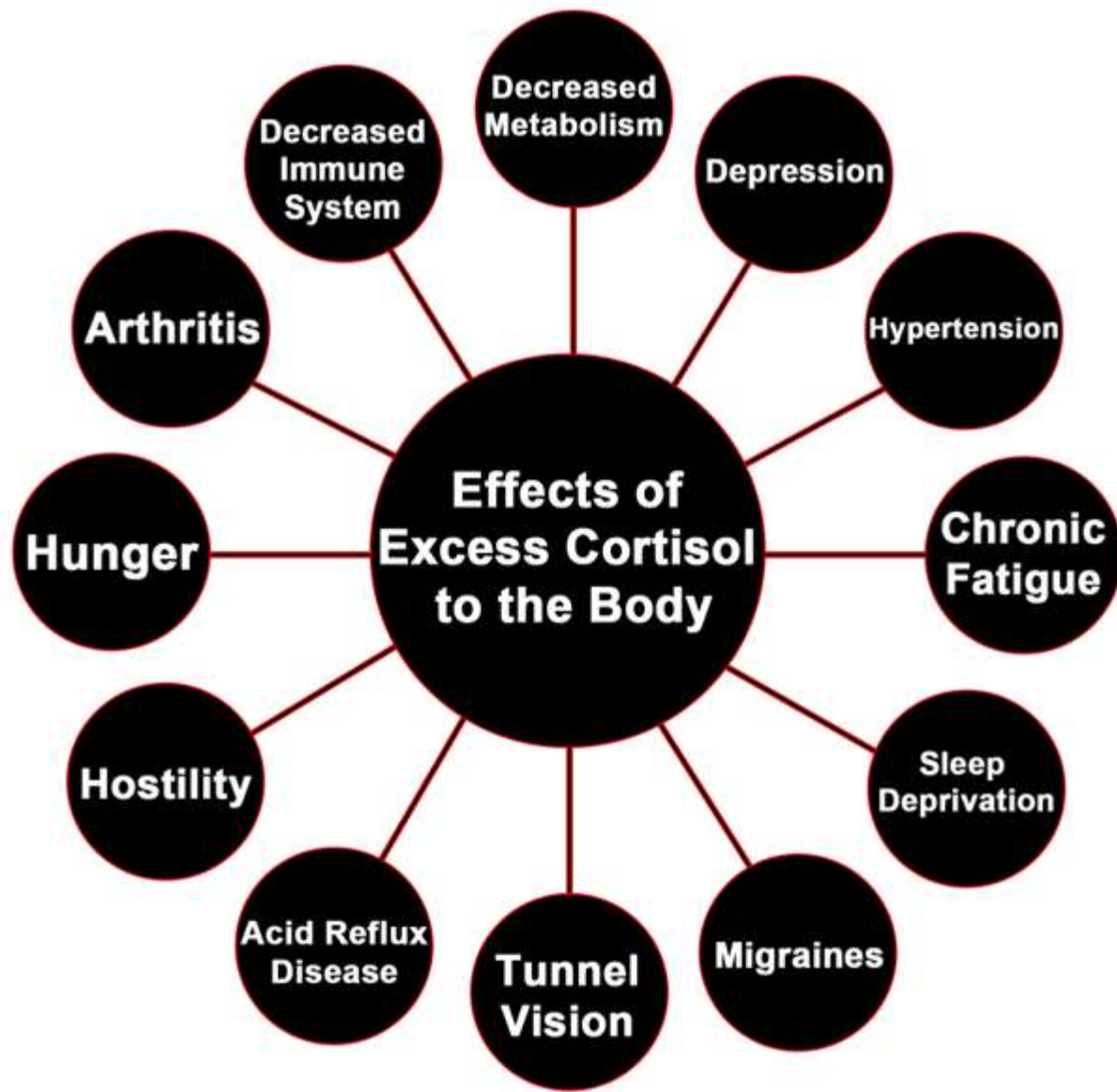




**Cortisol** is the major glucocorticoid in humans.

2 primary **actions**:  
Stimulates gluconeogenesis—the breakdown of protein and fat to provide metabolites that can be converted to glucose in the liver—and

Activates anti-stress and anti-inflammatory pathways.



**Cortisol - The Stress Hormone**

# **SLEEP DEPRIVATION**

## **EFFECTS**

- **Early reports of bizarre or psychotic behavior**
- **Most common effects of sleep deprivation:**
  - increased irritability
  - decreased concentration
  - Confusion/disorientation

# SLEEP DEPRIVATION

## EFFECTS

SAFETY



6,000

FATAL CAR  
CRASHES  
CAUSED  
BY DROWSY  
DRIVING  
EACH YEAR



1<sup>IN</sup> 25

ADULTS  
WHO'VE FALLEN  
ASLEEP AT THE  
WHEEL IN THE  
PAST MONTH



# SLEEP DEPRIVATION

## EFFECTS

WEIGHT



**MORE CRAVINGS**  
FOR SWEET, SALTY  
& STARCHY FOOD



Higher levels  
of the **hunger**  
**hormone ghrelin**



Lower levels of the  
**appetite-control**  
**hormone leptin**

**50%**

HIGHER RISK FOR OBESITY  
IF YOU GET LESS THAN 5  
HOURS OF SLEEP NIGHTLY

# SLEEP DEPRIVATION

## EFFECTS

### HEALTH



LESS  
ACTIVE  
IMMUNITY  
PROTECTORS  
CALLED  
NATURAL  
KILLER CELLS

36%

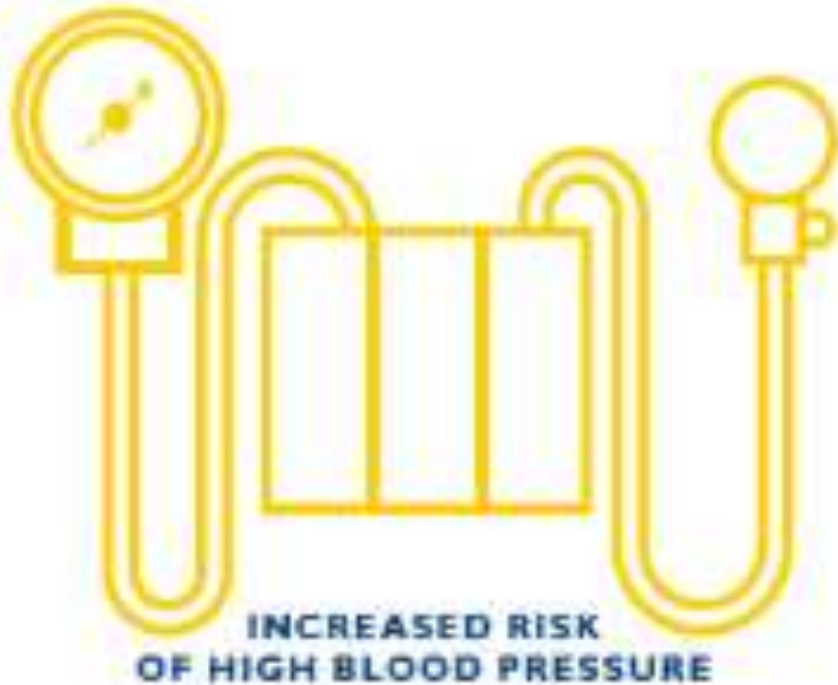
INCREASE  
IN RISK FOR  
COLORECTAL  
CANCER

NEARLY  
3X

RISK FOR  
TYPE 2  
DIABETES

# SLEEP DEPRIVATION

## EFFECTS



48%

INCREASE IN  
DEVELOPING  
HEART DISEASE



3X

MORE LIKELY  
TO CATCH  
A COLD



# SLEEP DEPRIVATION

## EFFECTS

### BRAIN EFFECTS



33%

INCREASE IN  
DEMENTIA RISK



### GREATER RISK FOR:

- Depression
- Irritability
- Anxiety
- Forgetfulness
- Fuzzy thinking

# Depression and Sleep: Understanding the Connection



- People with insomnia have a higher risk of **depression**.
- On the other hand, depression can trigger **sleep problems**.
- **Knowing the connection** between depression and sleep can help you recognize symptoms and **get treatment for both**.

# **Clock summary**

- **Genes control pacemaker, the Supra Chiasm Nucleus (SCN)**
- **SCN occurs in vertebrates, but is distributed in brain cells in some insects**
- **SCN signals pineal to release melatonin from pineal cells**
- **Light – the cause for circadian rhythm to commence**
- **The whole hypothalamus region of brain controls host of biological effects – SLEEP & Other Effects**
- **Circadian rhythm has roots in neuro-hormonal, neuro-chemical & genetic predisposition.**

**LET US WATCH THE VIDEO**

**Satchin Panda, Ph.D.**

