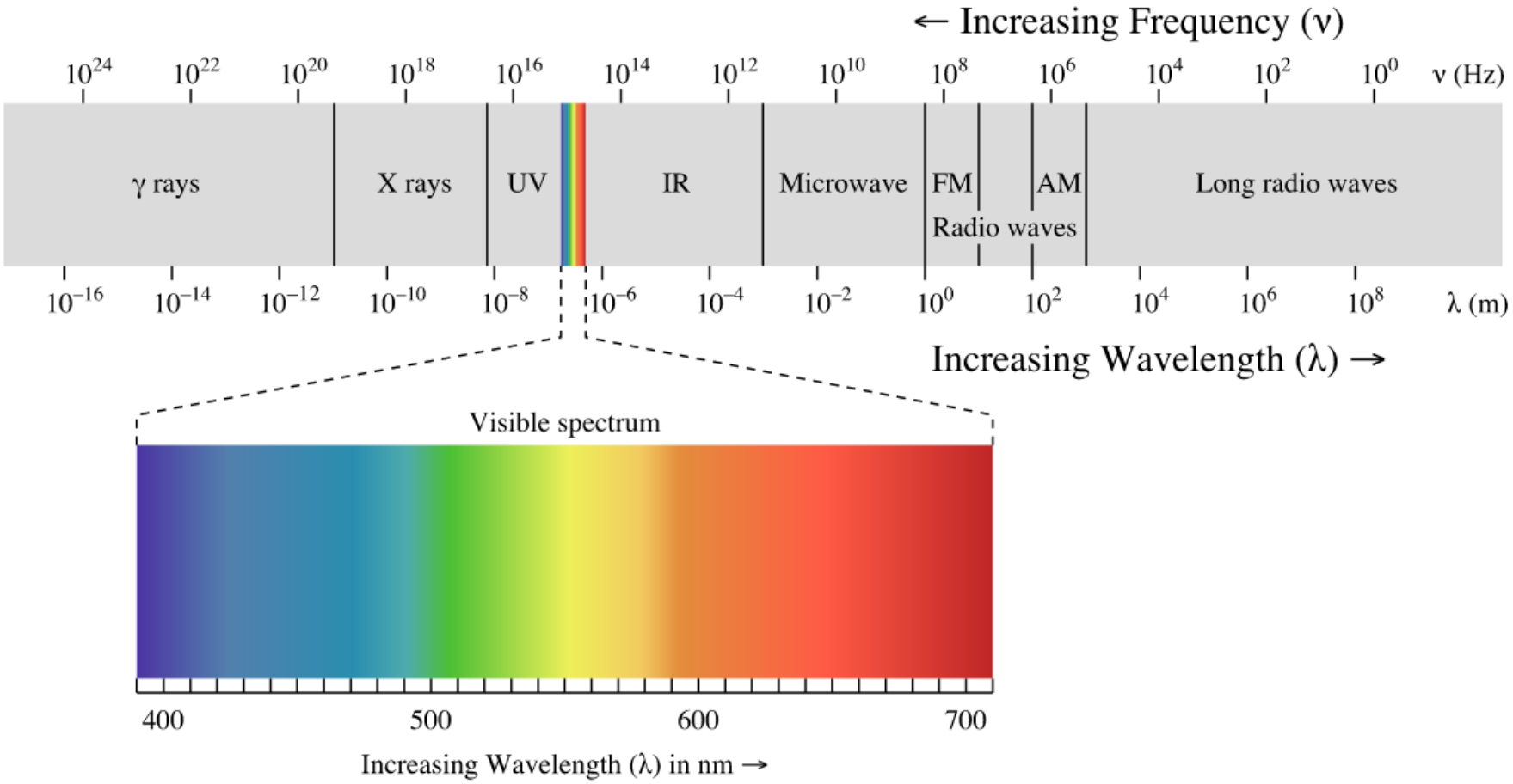
9
Vision I

Light

Electromagnetic radiation with wavelengths in range of 400 – 700 nm



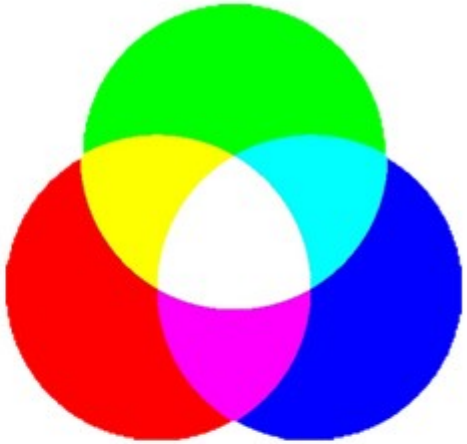
https://upload.wikimedia.org/wikipedia/commons/f/f1/EM_spectrum.svg

Color mixing

RGB
Additive Color

mixing light

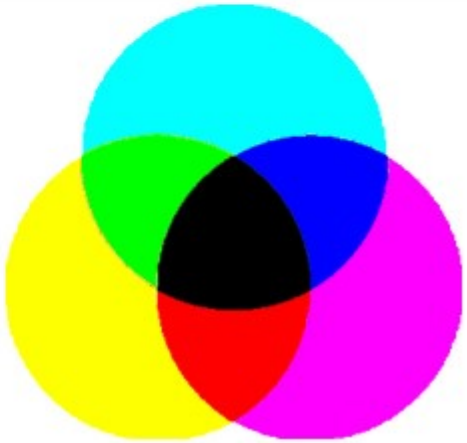
RED GREEN BLUE



CMYK
Subtractive Color

mixing ink

CYAN MAGENTA YELLOW



http://www.indiana.edu/~jkmedia/classes/images/colormodes.jpg

Photoreceptive organ

✓Light detection

✓Image formation

Light detection

- Circadian activity
  - Both prokaryotes and eukaryotes
  - Day/night cycle is the most influential and the most stable biorhythm

Light detection

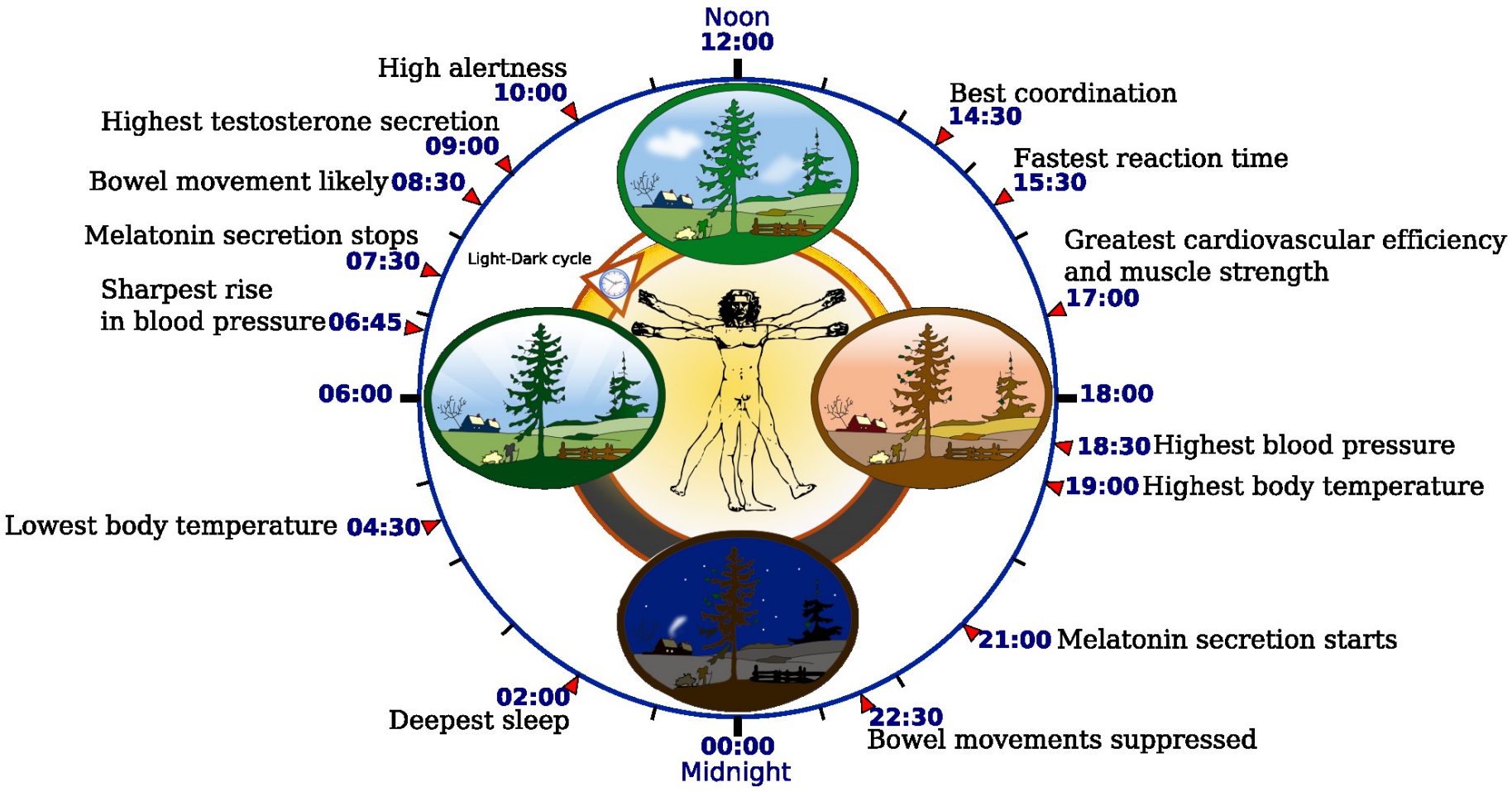
- Circadian activity
  - Both prokaryotes and eukaryotes
  - Day/night cycle is the most influential and the most stable biorhythm

Light/dark
↓
„warm/cold“

Light detection

- Circadian activity
  - Both prokaryotes and eukaryotes
  - Day/night cycle is the most influential and the most stable biorhythm
  - Oscillation with a period of aprox. 24 hours even without signals from environment
  - Environmental signals synchronize circadian activity
- Seasonal activity

Light/dark
↓
„warm/cold“



https://upload.wikimedia.org/wikipedia/commons/thumb/3/30/Biological_clock_human.svg/2000px-Biological_clock_human.svg.png

Biological clock

- Cellular level
  - Group of proteins rhythmically expressed creating interconnected feedback loops (about 24hours)
    - Peripheral Clock protein expression

Biological clock

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  - Influenced by neurohumoral factors and also by light

Biological clock

- Cellular level
  - Group of proteins rhythmically expressed creating interconnected feedback loops (about 24hours)
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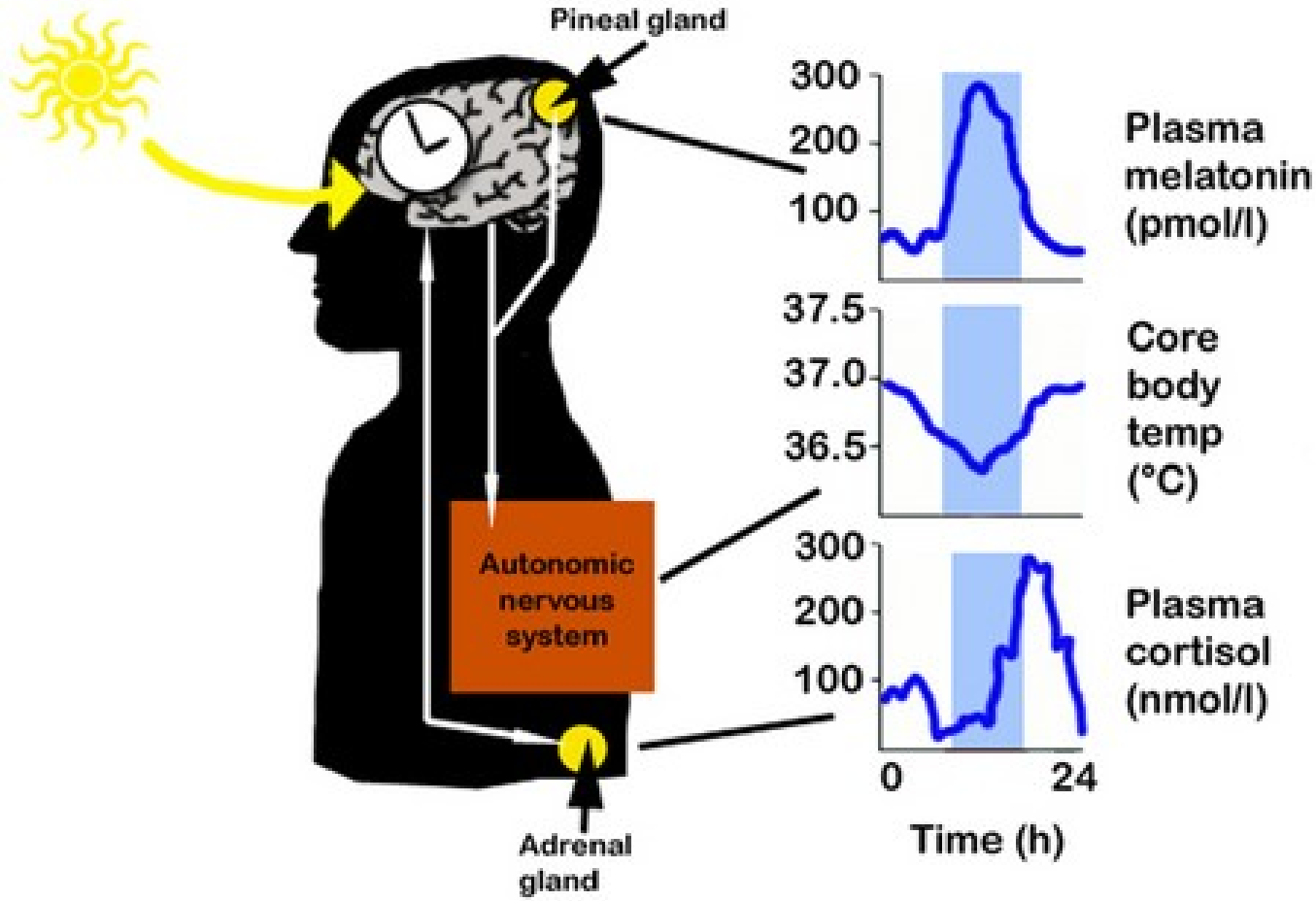
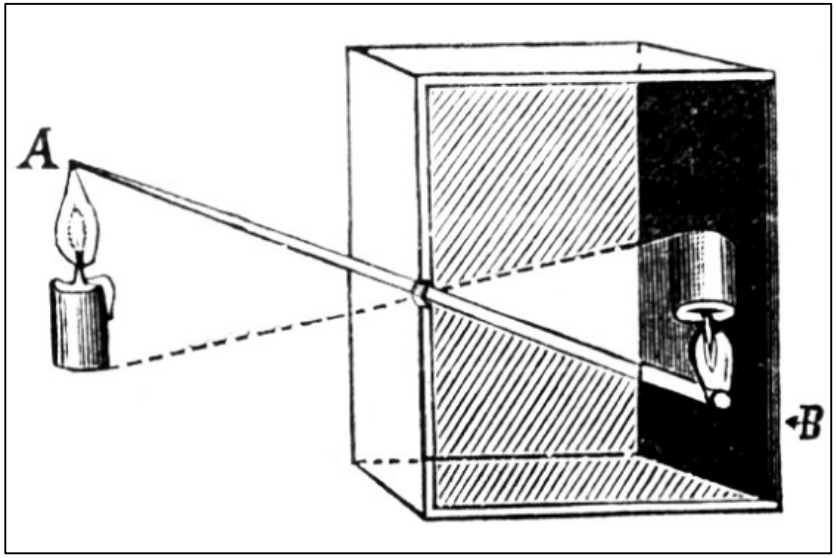
- Tissue level
  - Peripheral oscillators
  - Adrenal gland, lung, liver, pancreas, skin
  - Influenced by neurohumoral factors and also by light
- Central pacemaker
  - Hypothalamus (nucleus suprachiasmaticus)
    - Central clock protein expression
    - Information about illumination from retina (specialized ganglion cells) – synchronization of central pacemaker
  - ➢ Pineal gland - melatonin
  - ➢ Autonomnic nervous system – adreanl gland - cortisol



A.J. Hesse, G.E. Duffield adapted from Hastings, M. BMJ 1998;317:1704-1707

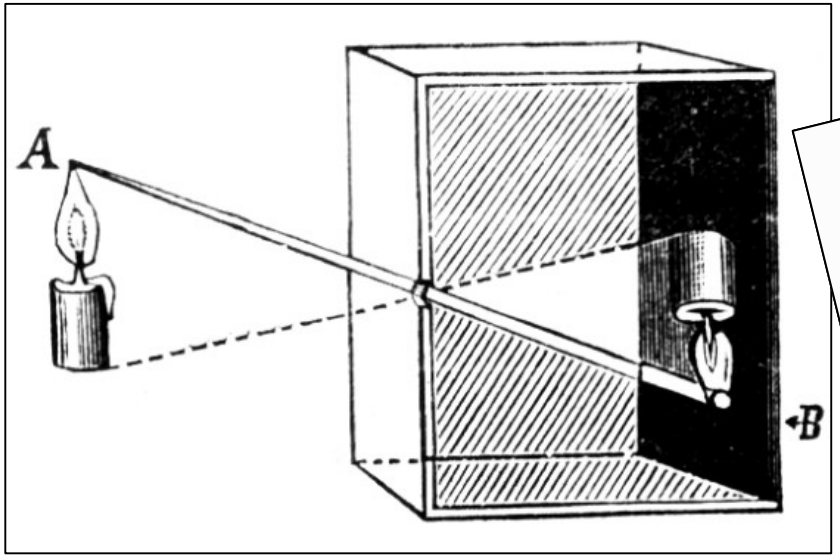
http://slideplayer.com/slide/7013288/

Image formation



https://www.fotoskoda.cz/images/manufacturers/camera_obscura.png

Image formation



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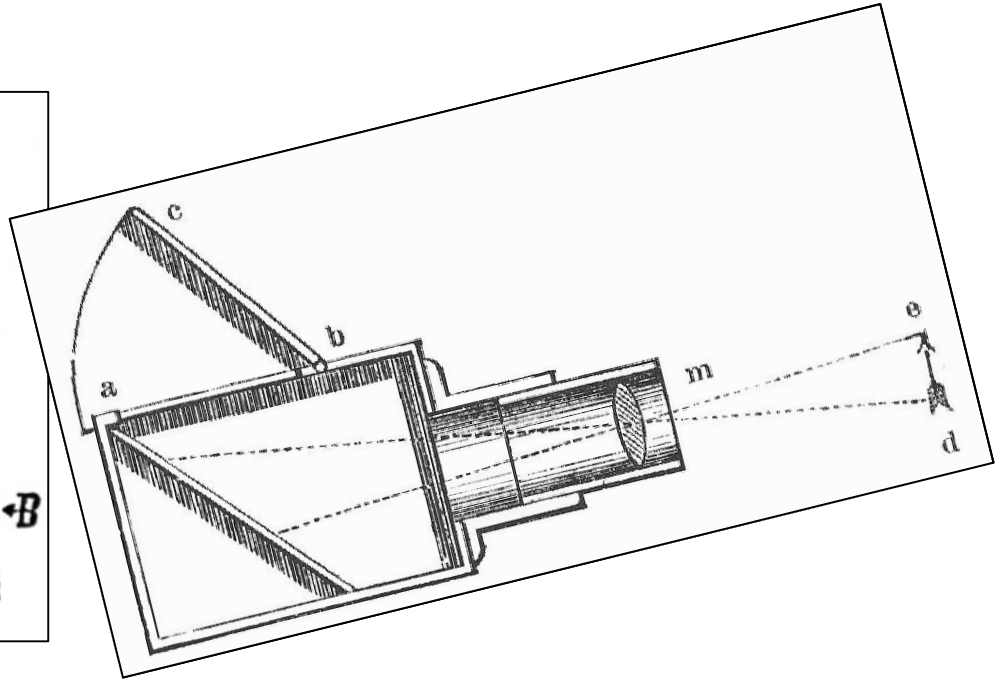
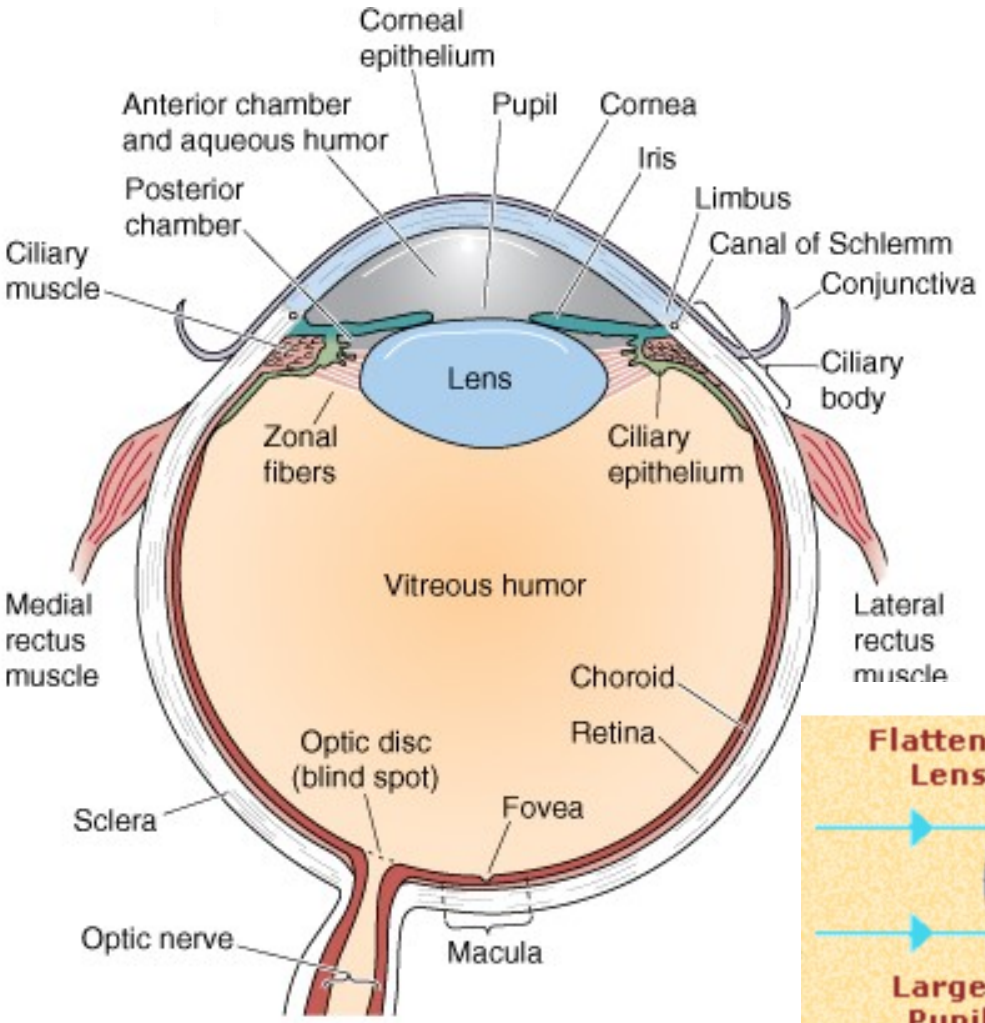


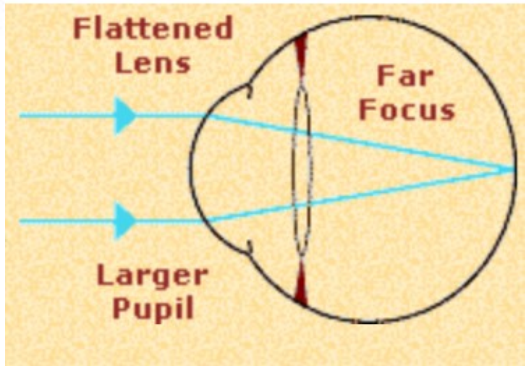
http://de.academic.ru/pictures/meyers/large/030717c.jpg

Image formation



- Shape
- Color
- Localization
- Movement

- Image interpretation



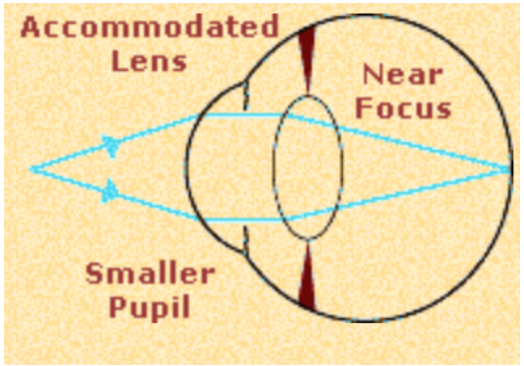
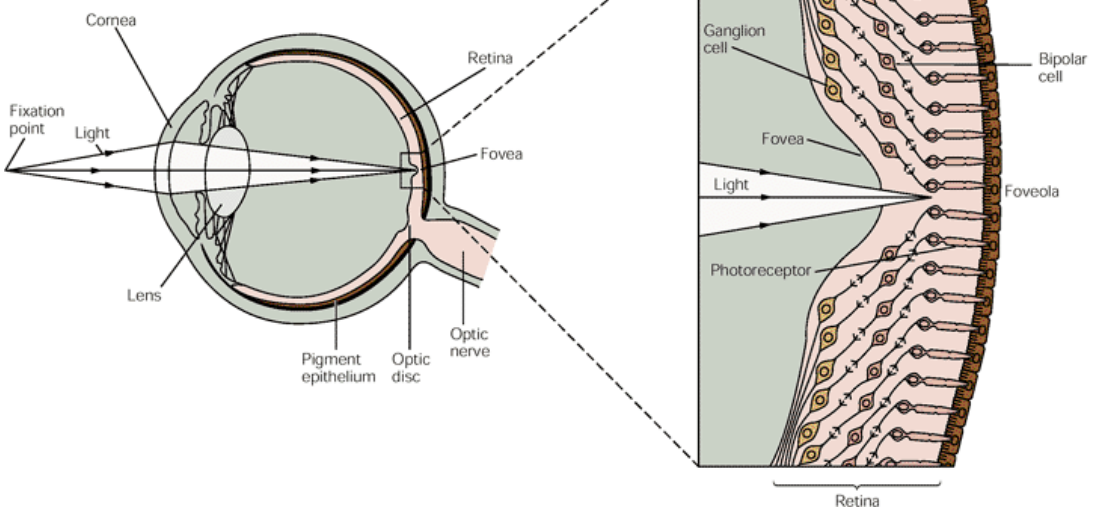


Image formation



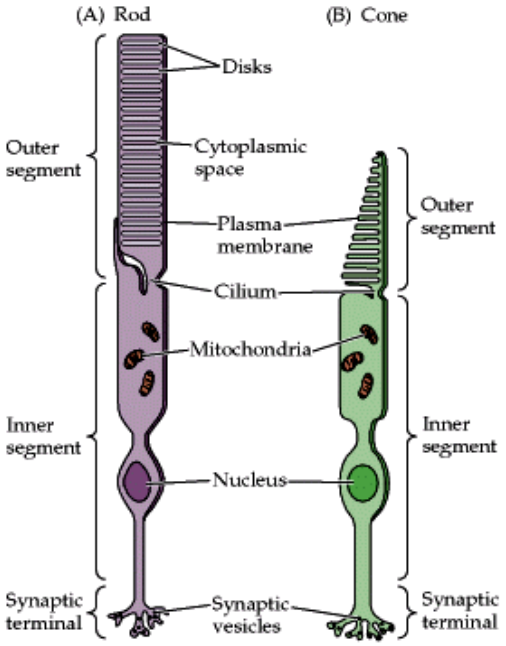
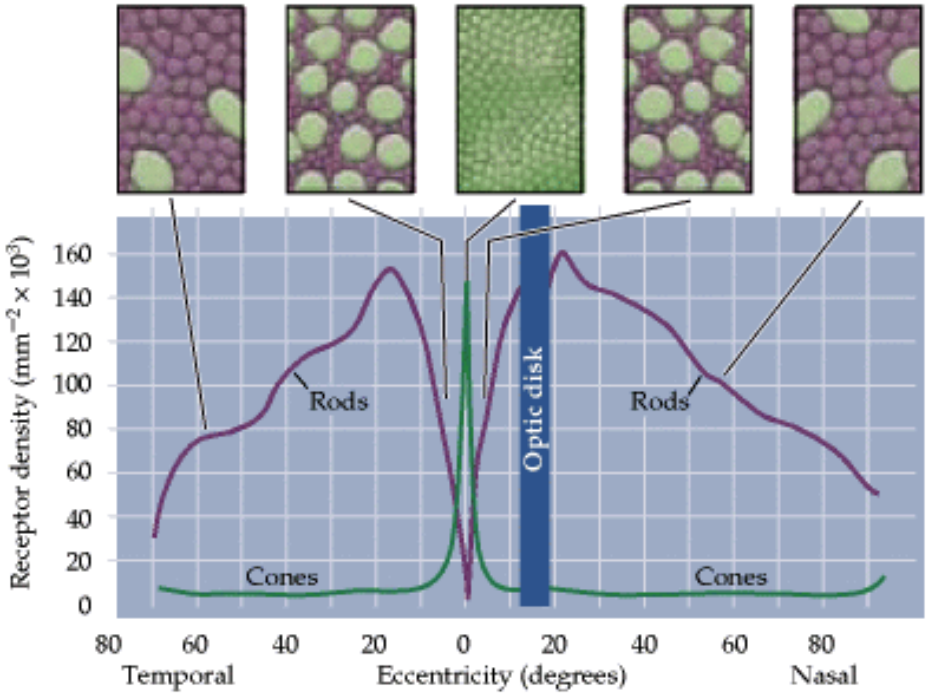
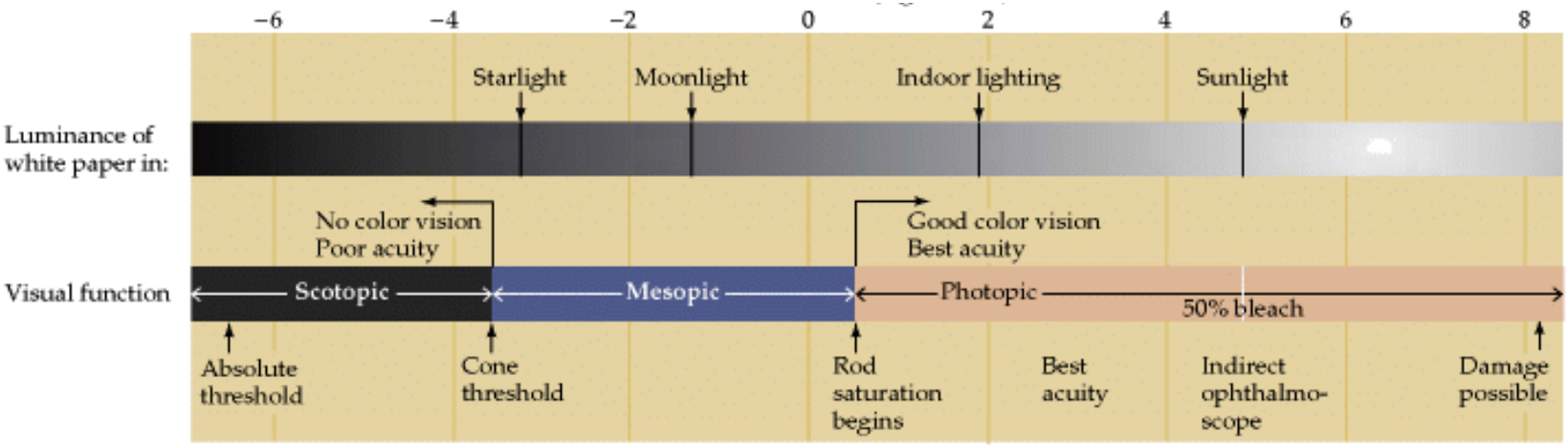


Table 26-1 Differences Between Rods and Cones and Their Neural Systems

Rods	Cones
High sensitivity to light, specialized for night vision	Lower sensitivity, specialized for day vision
More photopigment, capture more light	Less photopigment
High amplification, single photon detection	Lower amplification
Low temporal resolution: slow response, long integration time	High temporal resolution: fast response, short integration time
More sensitive to scattered light	Most sensitive to direct axial rays
Rod system	**Cone system**
Low acuity: not present in central fovea, highly convergent retinal pathways	High acuity: concentrated in fovea, dispersed retinal pathways
Achromatic: one type of rod pigment	Chromatic: three types of cones, each with a distinct pigment that is most sensitive to a different part of the visible light spectrum

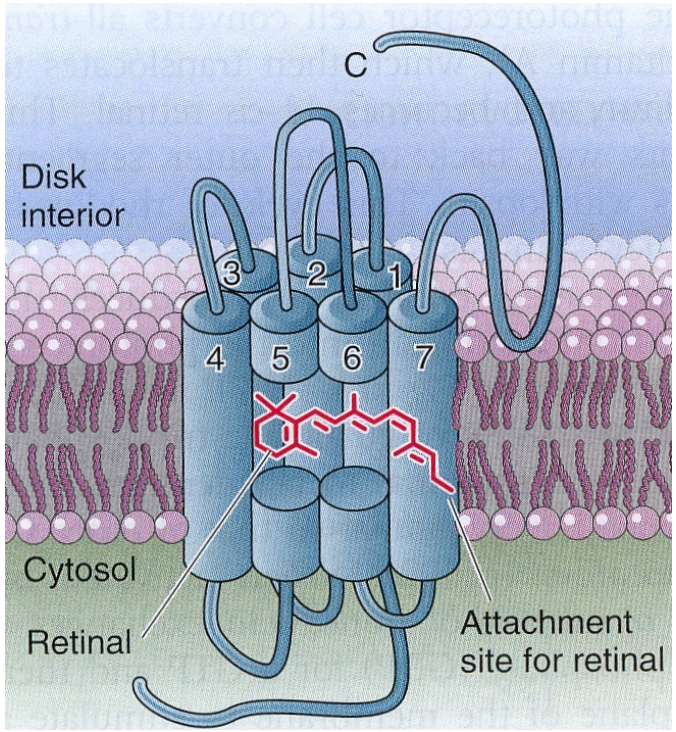

Receptor density (mm^{-2} × 10^3)
160
140
120
100
80
60
40
20
0
Rods
Rods
Optic disk
Cones
Cones
80 60 40 20 0 20 40 60 80
Temporal
Eccentricity (degrees)
Nasal

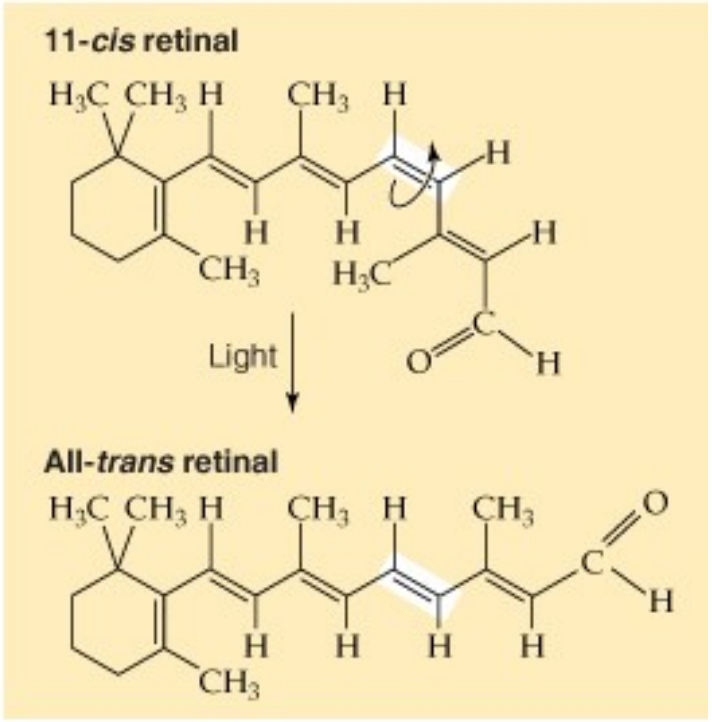

−6 −4 −2 0 2 4 6 8
Starlight
Moonlight
Indoor lighting
Sunlight
Luminance of white paper in:
No color vision
Poor acuity
Good color vision
Best acuity
Visual function
Scotopic
Mesopic
Photopic
50% bleach
Absolute threshold
Cone threshold
Rod saturation begins
Best acuity
Indirect ophthalmo-scope
Damage possible

Photopigment of rods

Rhodopsin

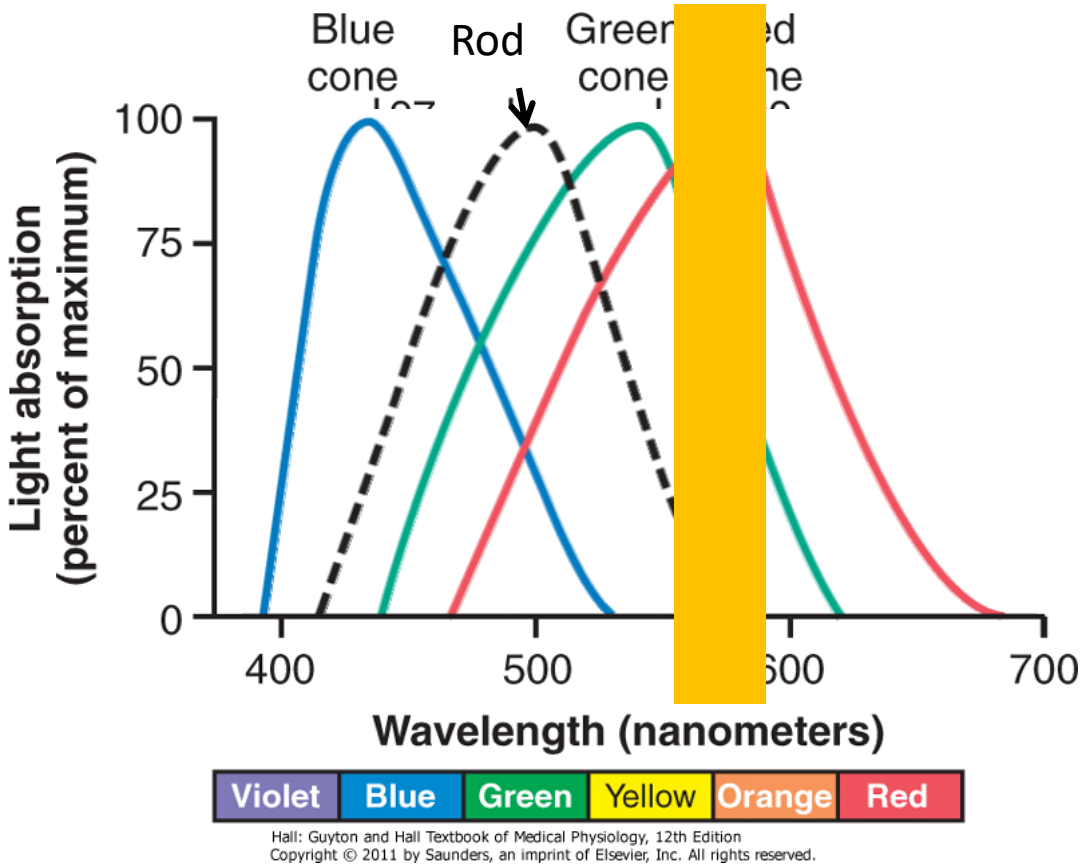
- Opsin
  - G – protein
- Retinal
  - Aldehyd retinolu (vit. A)





Photopigments of cones

- 3 types of cones - 3 types of photopigment
  - Blue(420nm)
  - Green (530nm)
  - Red (560nm)

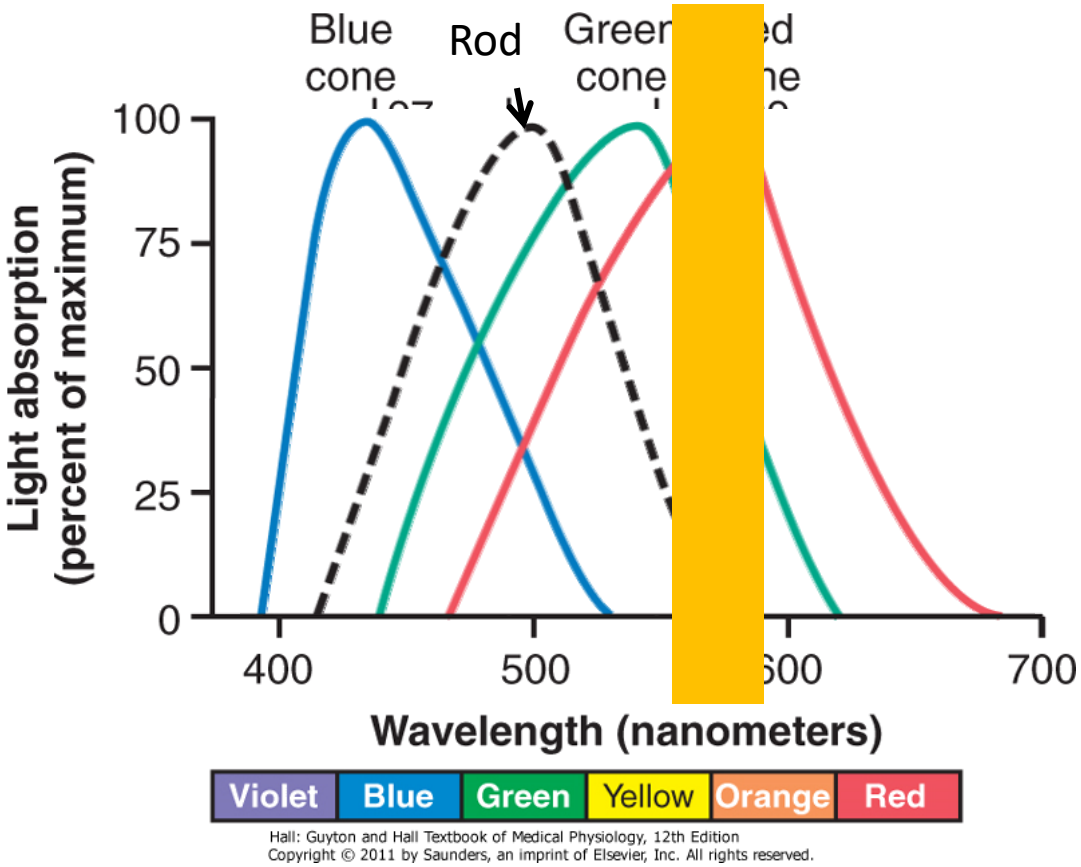


http://www.slideshare.net/CsillaEgri/presentations

Photopigments of cones

- 3 types of cones - 3 types of photopigment
  - Blue(420nm)
  - Green (530nm)
  - Red (560nm)

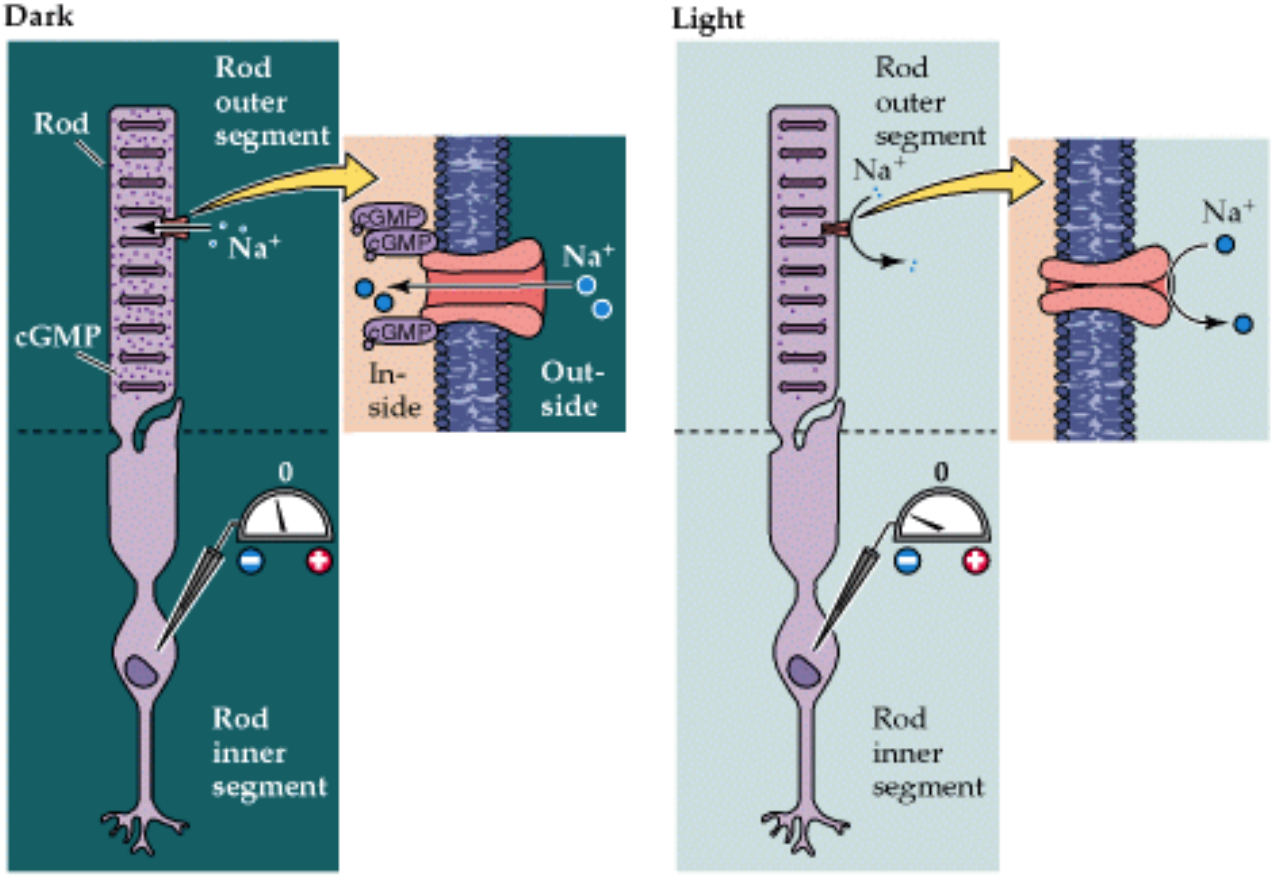
- Color is interpreted by ratio of cone stimulation
  - Orange (580nm)
    - Blue: 0%
    - Green: 42%
    - Red:99%



http://www.slideshare.net/CsillaEgri/presentations

Phototransduction

- Photoreceptors continuously release neurotransmitter (glutamate) in darkness
- In response to the light, the membrane **hyperpolarizes** and release less neurotransmitter

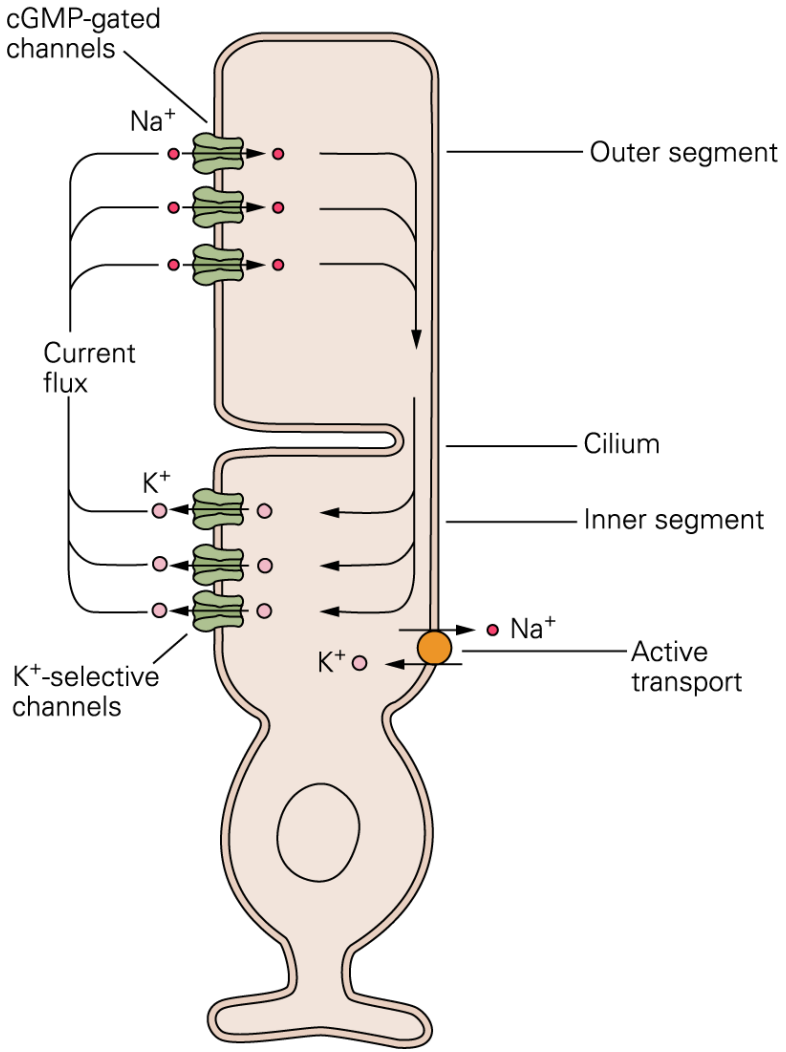


http://www.slideshare.net/drpsdeb/presentations

Phototransduction - darkness

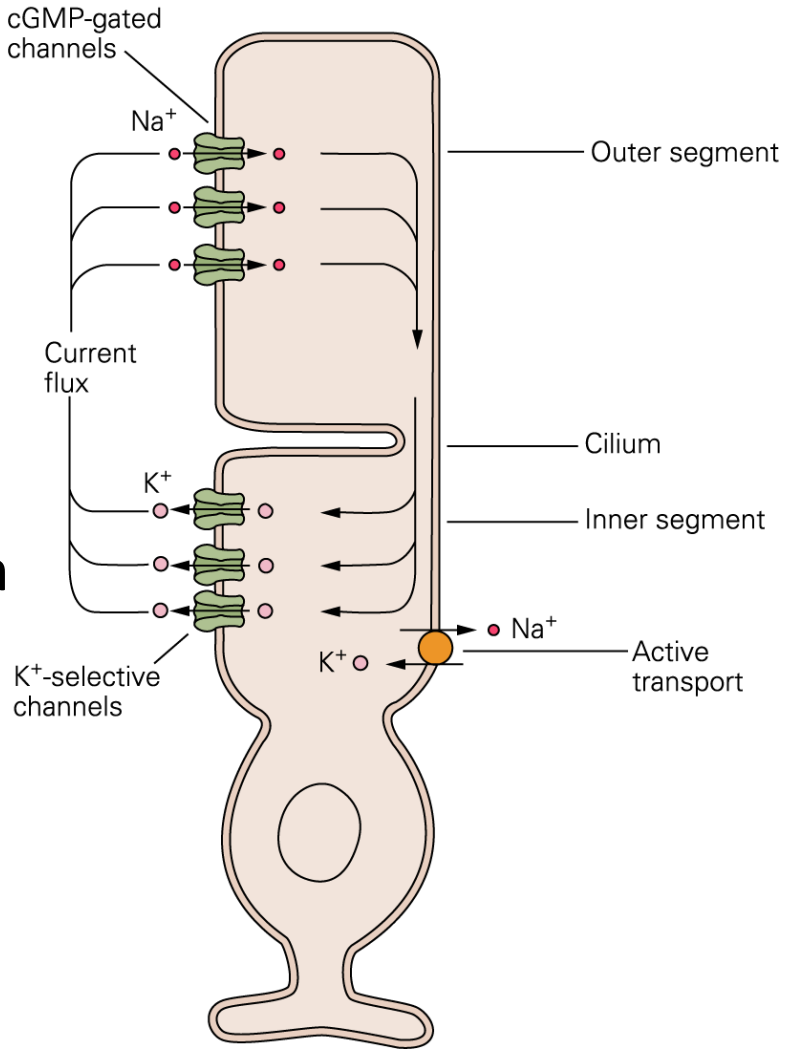
- Guanylate cyklase
  - cGMP
- cGMP-gated Na^+ channels
  - Na^+ influx
- Voltage gated Ca^{2+} channels
  - Release of glutamate

- The balance is kept by
  - K^+ efflux
  - Na^+/K^+ exchanger
- Resting membrane potential: – 40mV



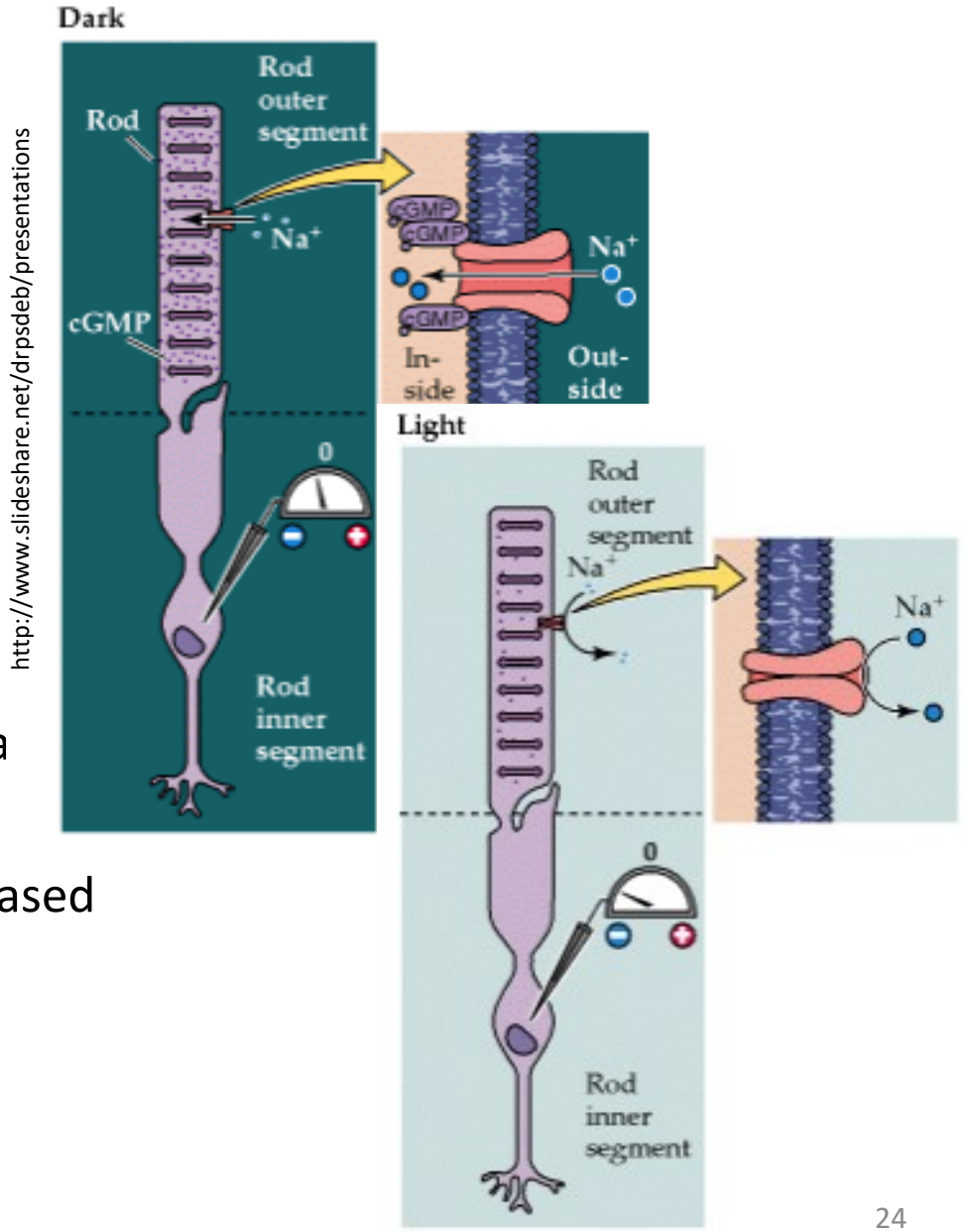
Phototransduction - light

- Photon is absorbed by photopigment
- Isomerization of retinal
- Cascade of reactions result in cGMP phosphodiesterase
  - cGMP levels decreased
- Deactivation of cGMP gated Na^+ chann
- K^+ efflux continues
- Membrane hyperpolarization
  - Deactivation of voltage Ca^{2+} channels
  - Decrease in glutamate release



Adaptation to the light/darkness

- **Optic adaptation**
  - Constriction of pupils
- **Photoreceptor adaptation**
  - Ca^{2+} inhibits guanylate cyclase
  - Light
    - Ca^{2+} decreased - cGMP increa
  - Darkness
    - Ca^{2+} increased – cGMP decreased
  - cGMP gated Na^{+} channels...



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