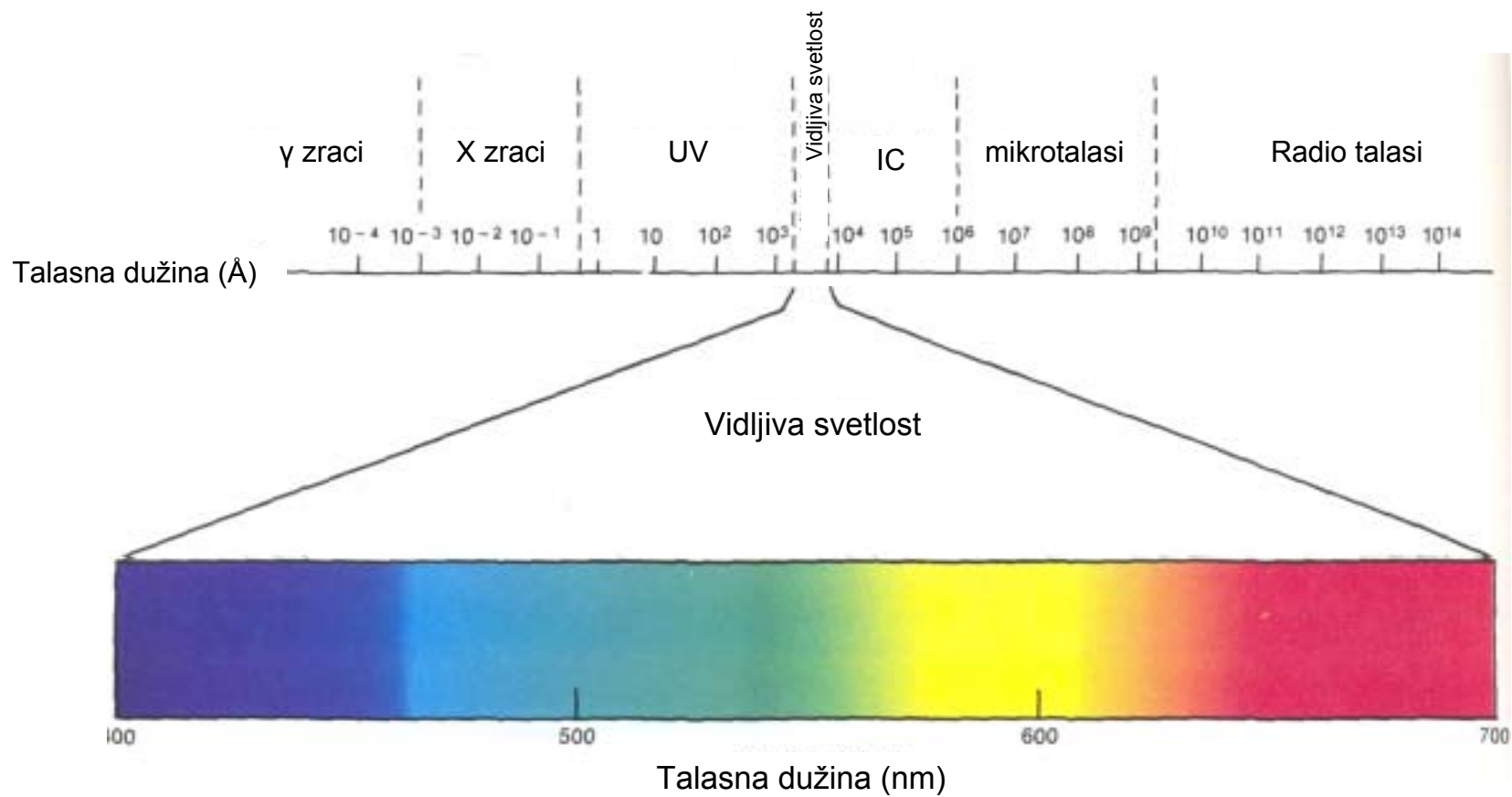


Neurofiziologija vida

Vidljiva svetlost



2. Tunica vascularis

Iris
Cililjarno telo
Chorioidea

Prednja
komora

Kornea
Sklera

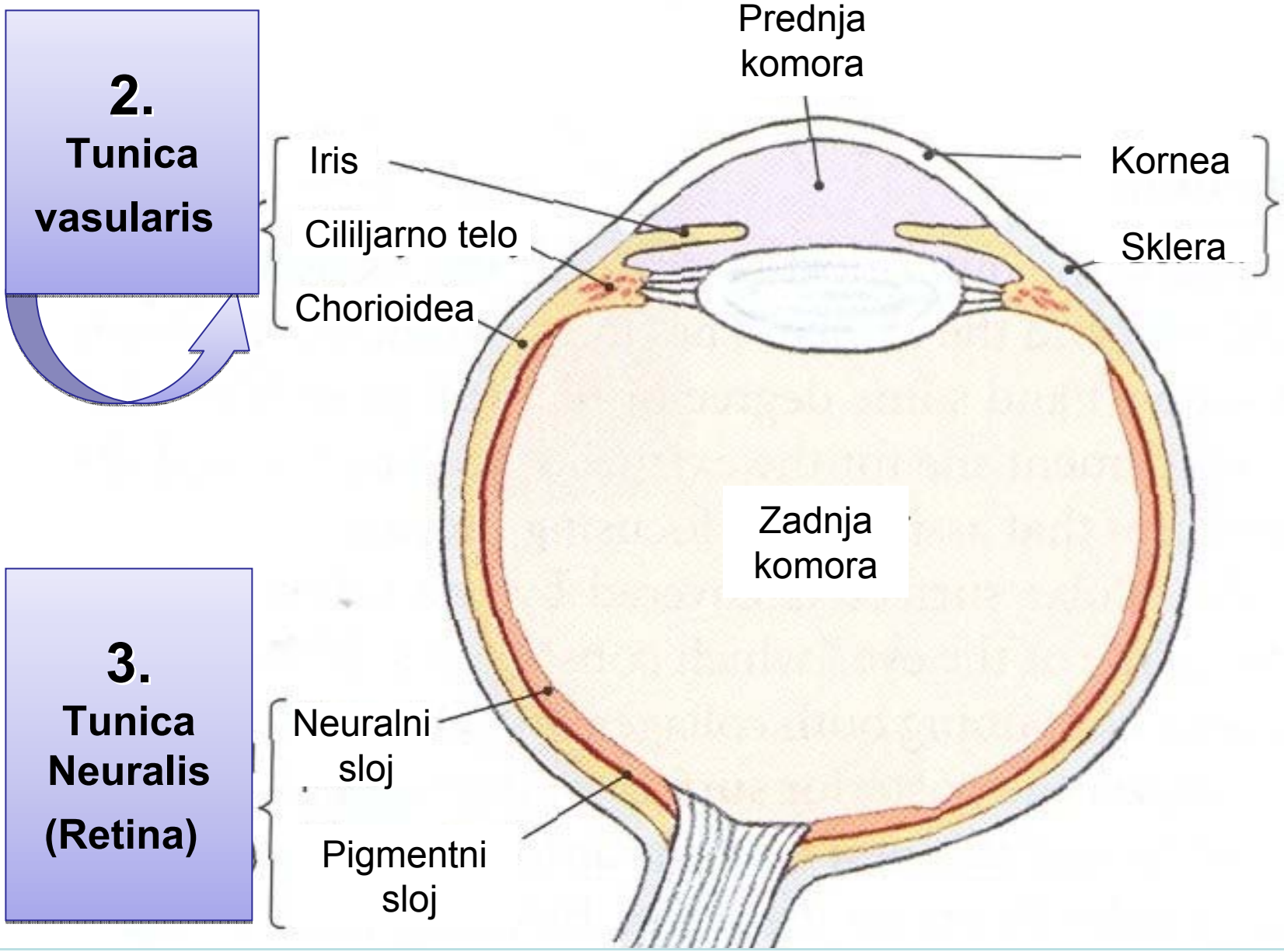
1. Tunica fibrosa

Zadnja
komora

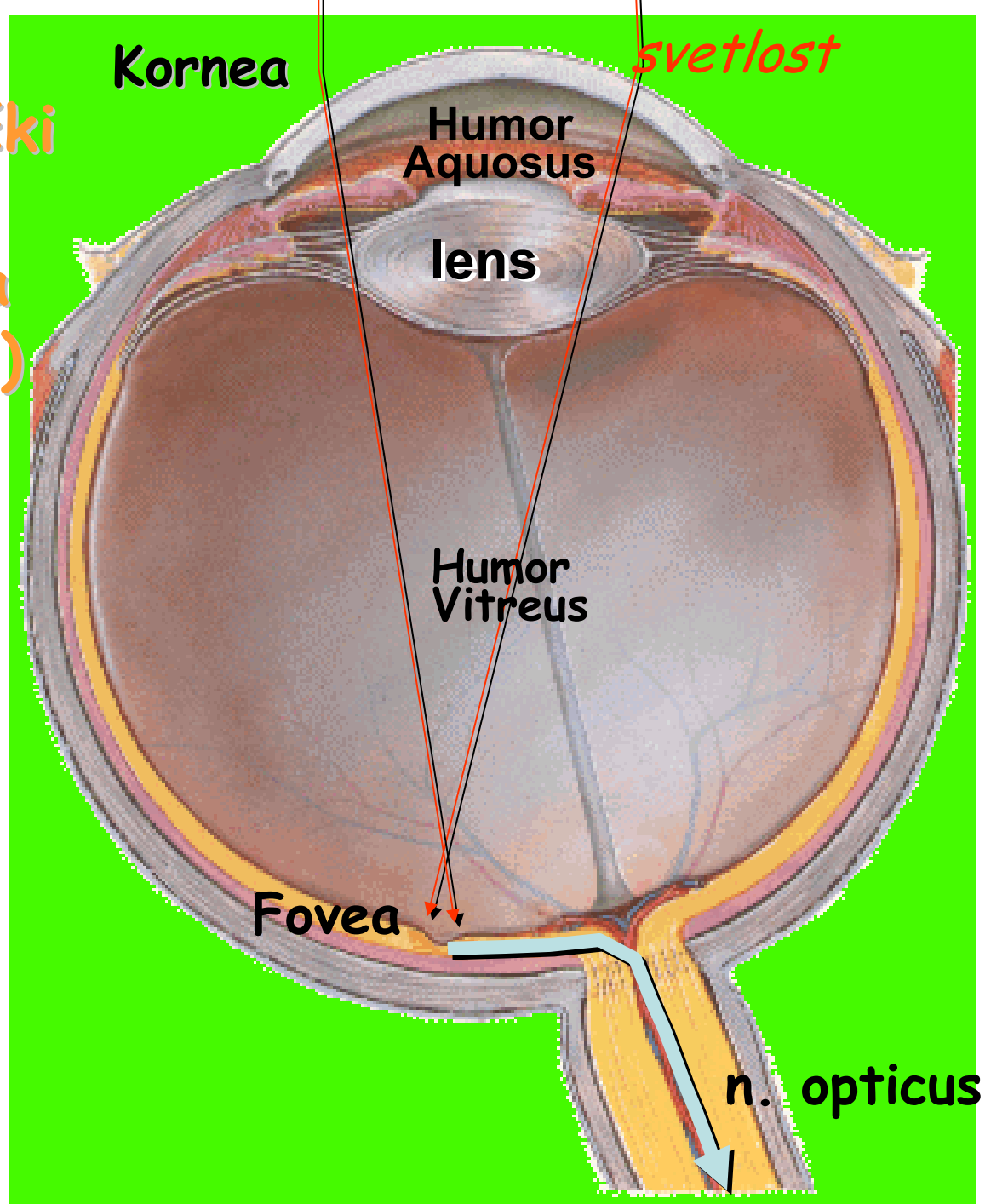
3. Tunica Neuralis (Retina)

Neuralni
sloj
Pigmentni
sloj

zraki putuju kroz vazduh brzinom od približno 300 000 km/s,



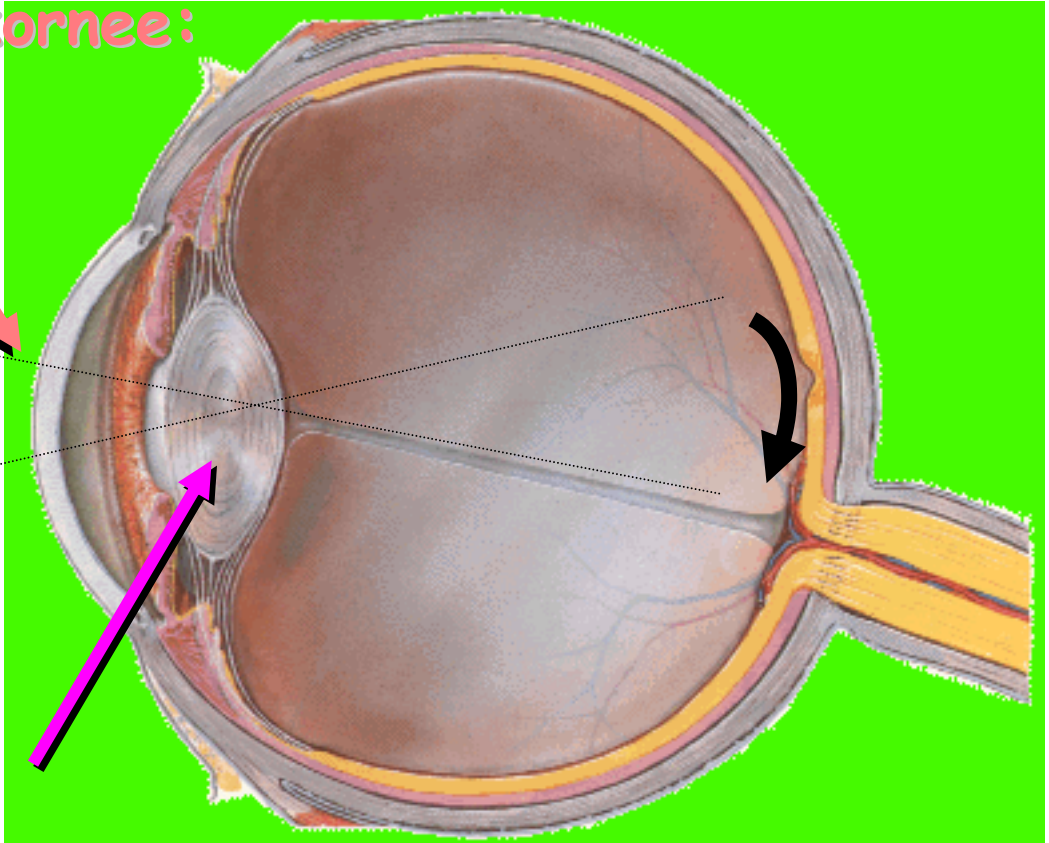
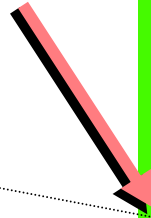
1)Dioptrički
Aparat
(prelomna
moć 59D)



Refrakciona moć dioptričkog aparata oka = 59D (58.64)

Indeks refrakcije
Zakrivljenost površine

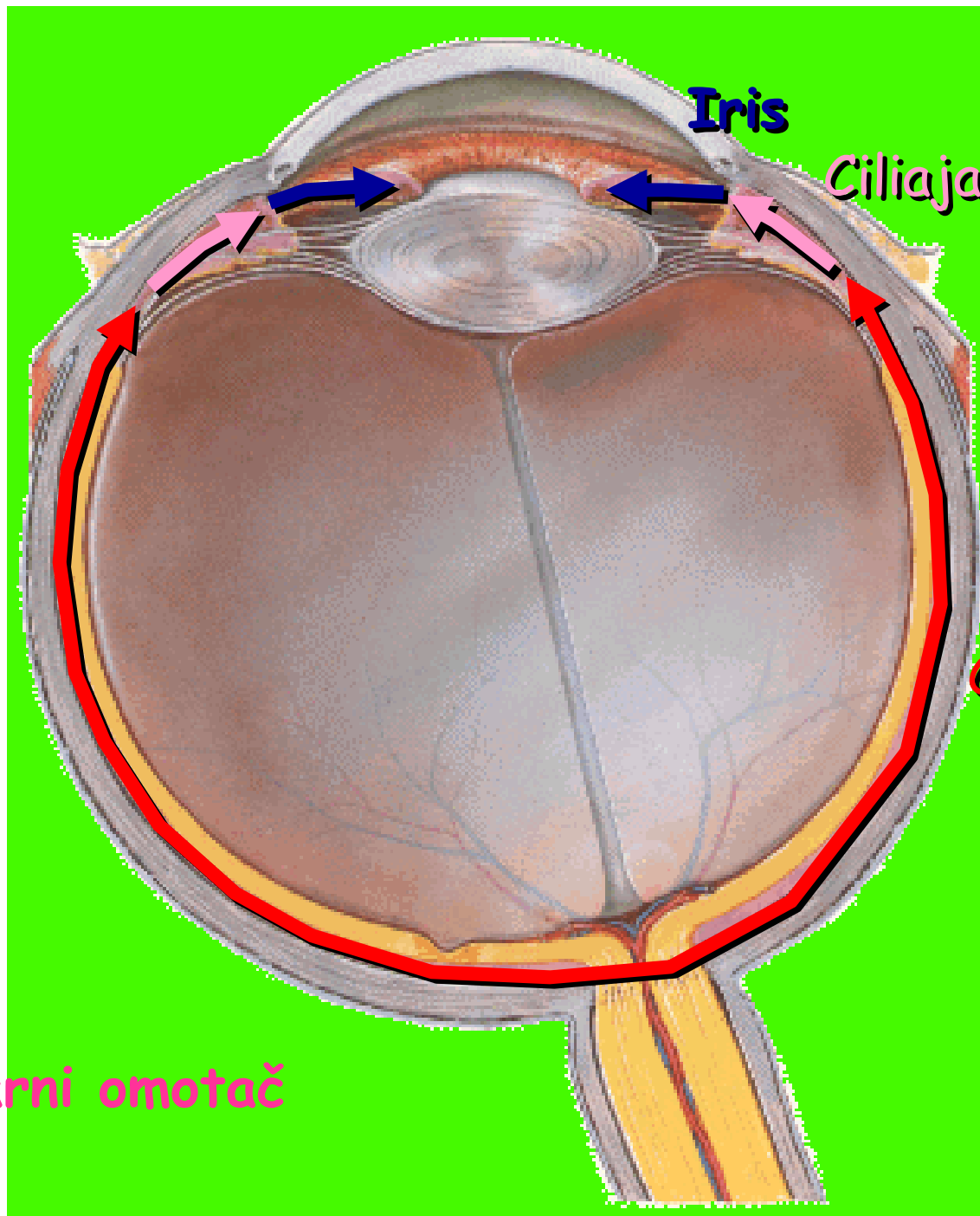
Refrakciona moć kornee:
80% = 43D



Refrakciona moć sočiva:
20% = 15 - 19D

+

Akomodacija



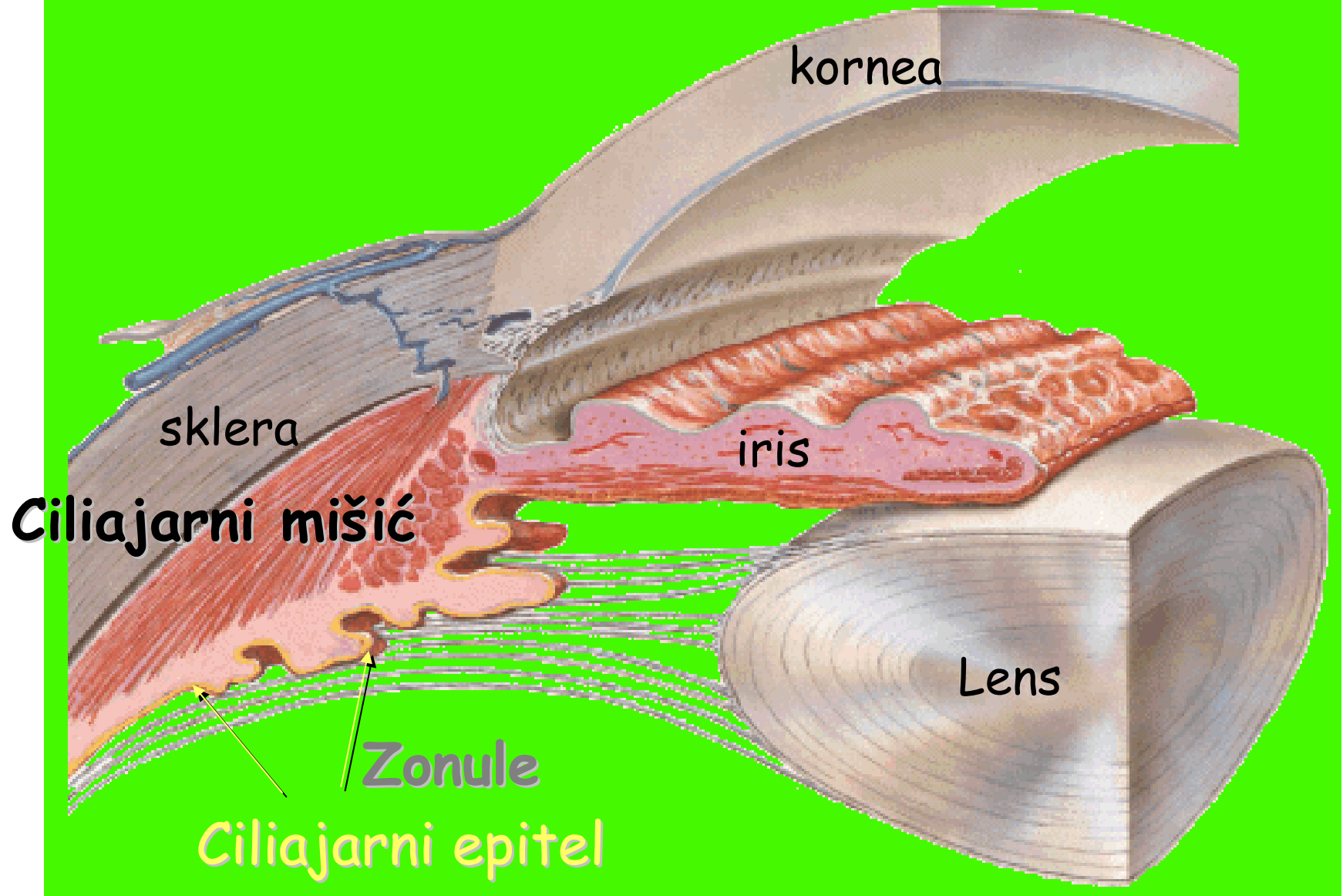
Iris

Ciliajarno telo

Choroid

2. Vaskularni omotač

Cilijarno telo

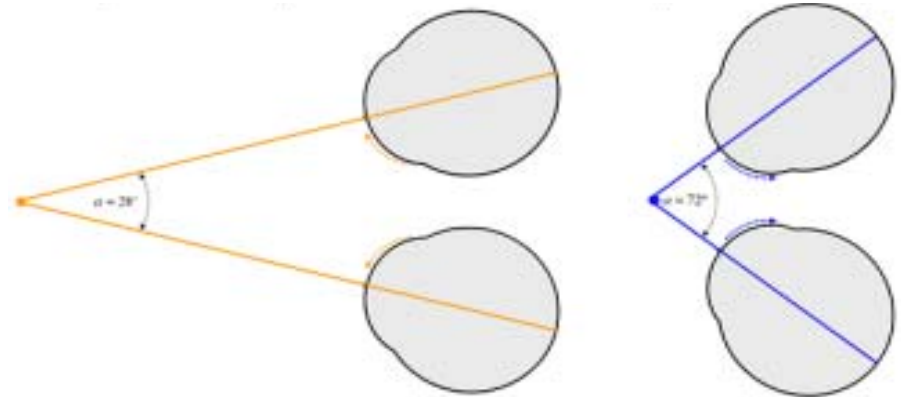


Akomodacija

Sposobnost jasnog
vidjenja bliskih
predmeta

1. Konvergencija
bulubusa

1.



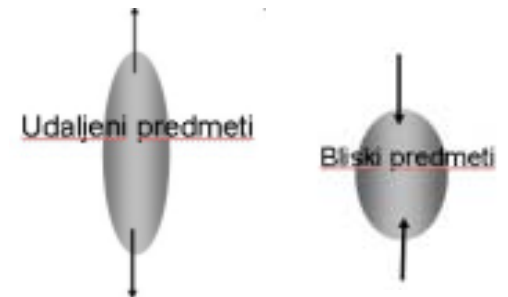
2. Mioza

2.

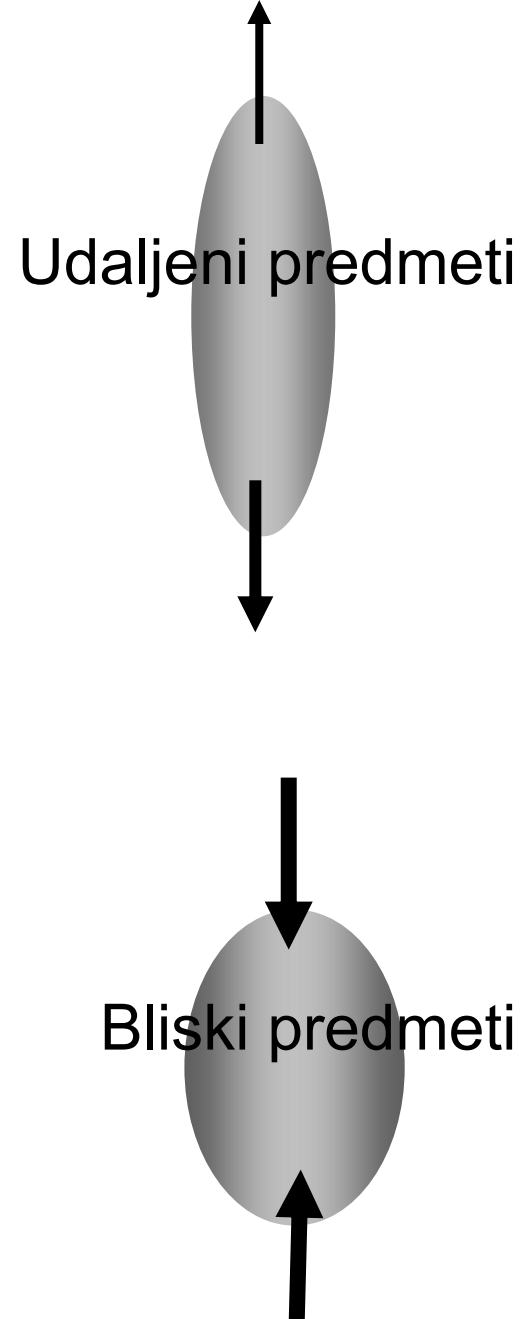
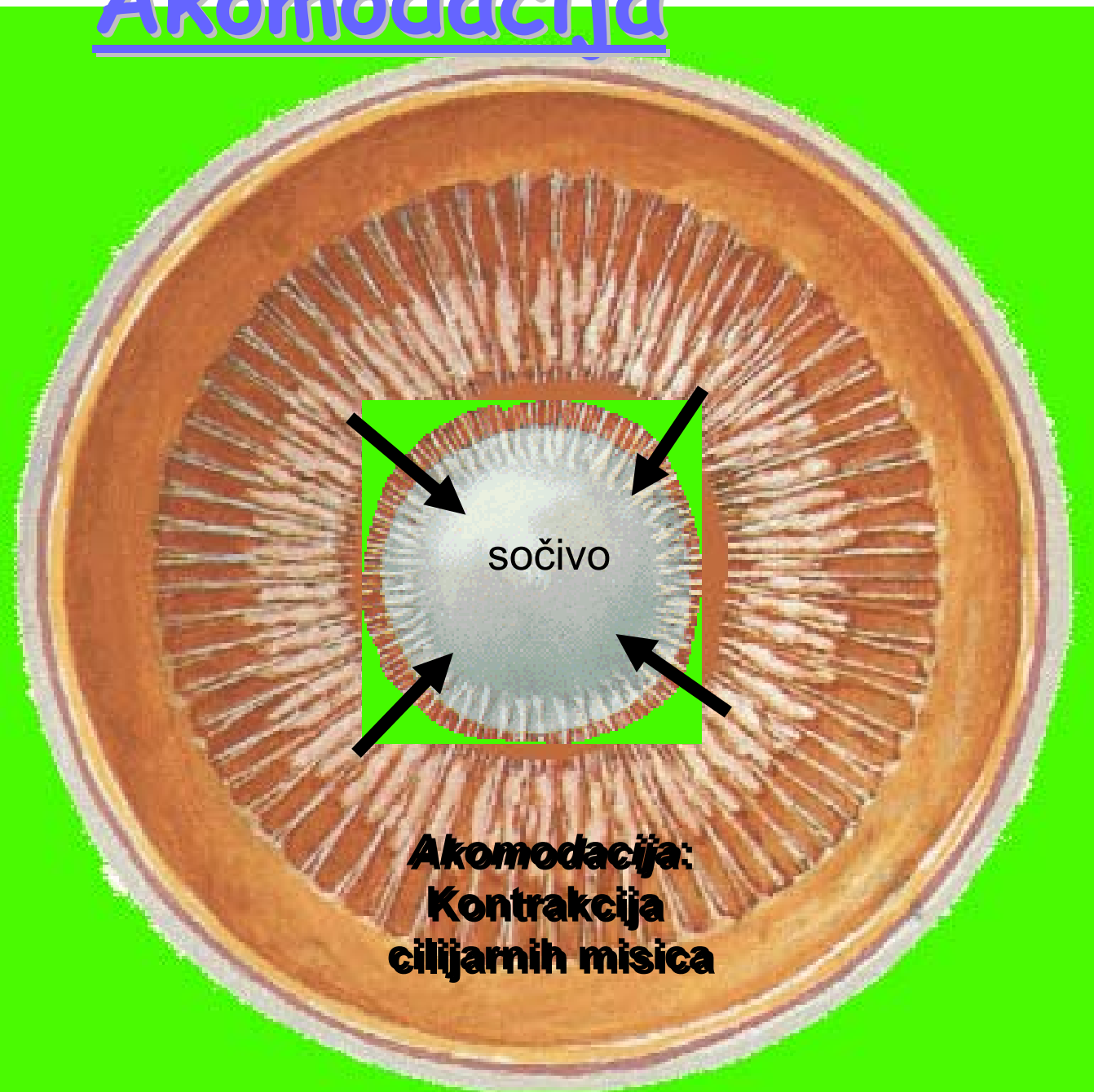


3. Zakrivljenost sočiva

3.



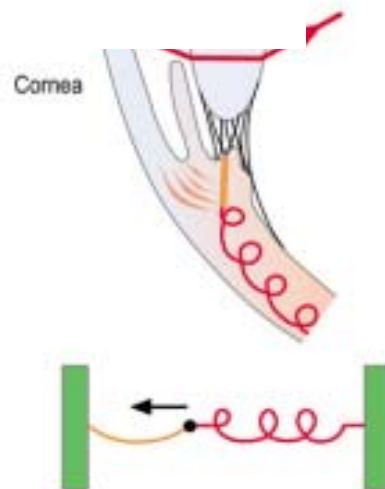
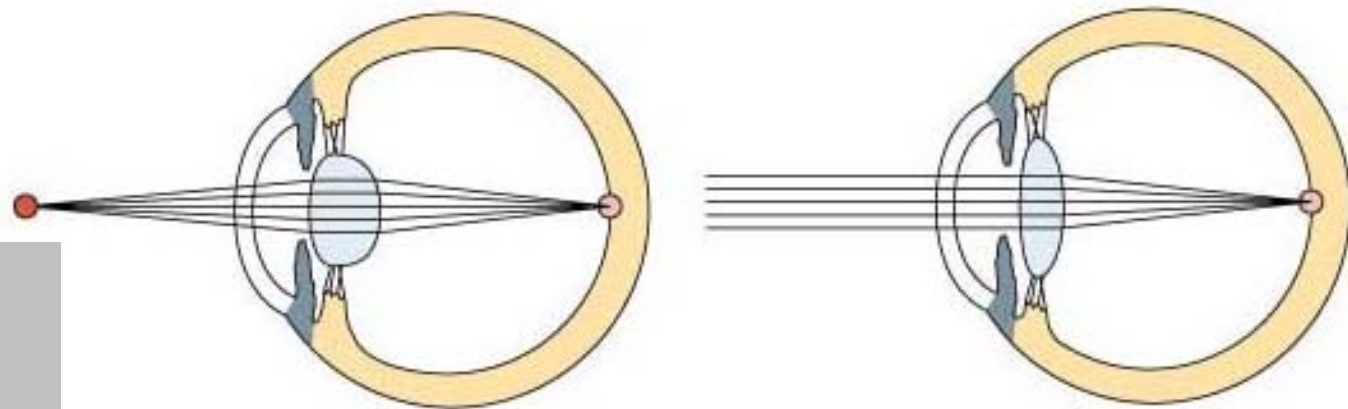
Akomodacija



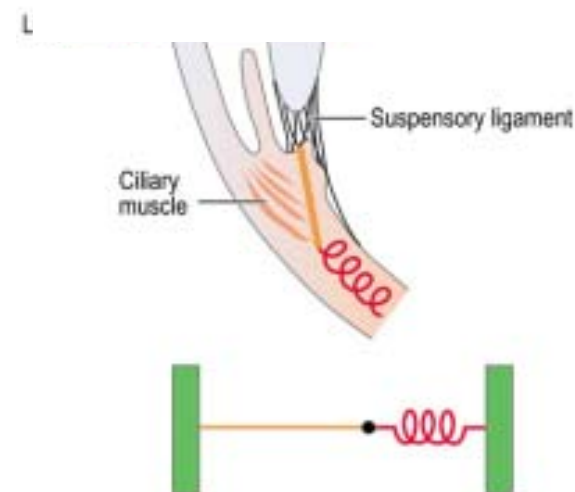
Kružna vlakna

deluju poput sfinktera smanjujući dijametar, kruga koji čine pripoji lig.

Parasimpatička n,
izaziva kontrakciju
oba snopa ciliarnog
mišića, što dovodi do
opuštanja lig,
povećanja zakrivljenosti
i
prelomne moć sočiva



KONTRAKCIJA CILIJARNOG MIŠIĆA,
OPUŠTANJE LIGAMENATA,
SOČIVO JE DEBELO - POSMATRANJE
NA BLIZINU



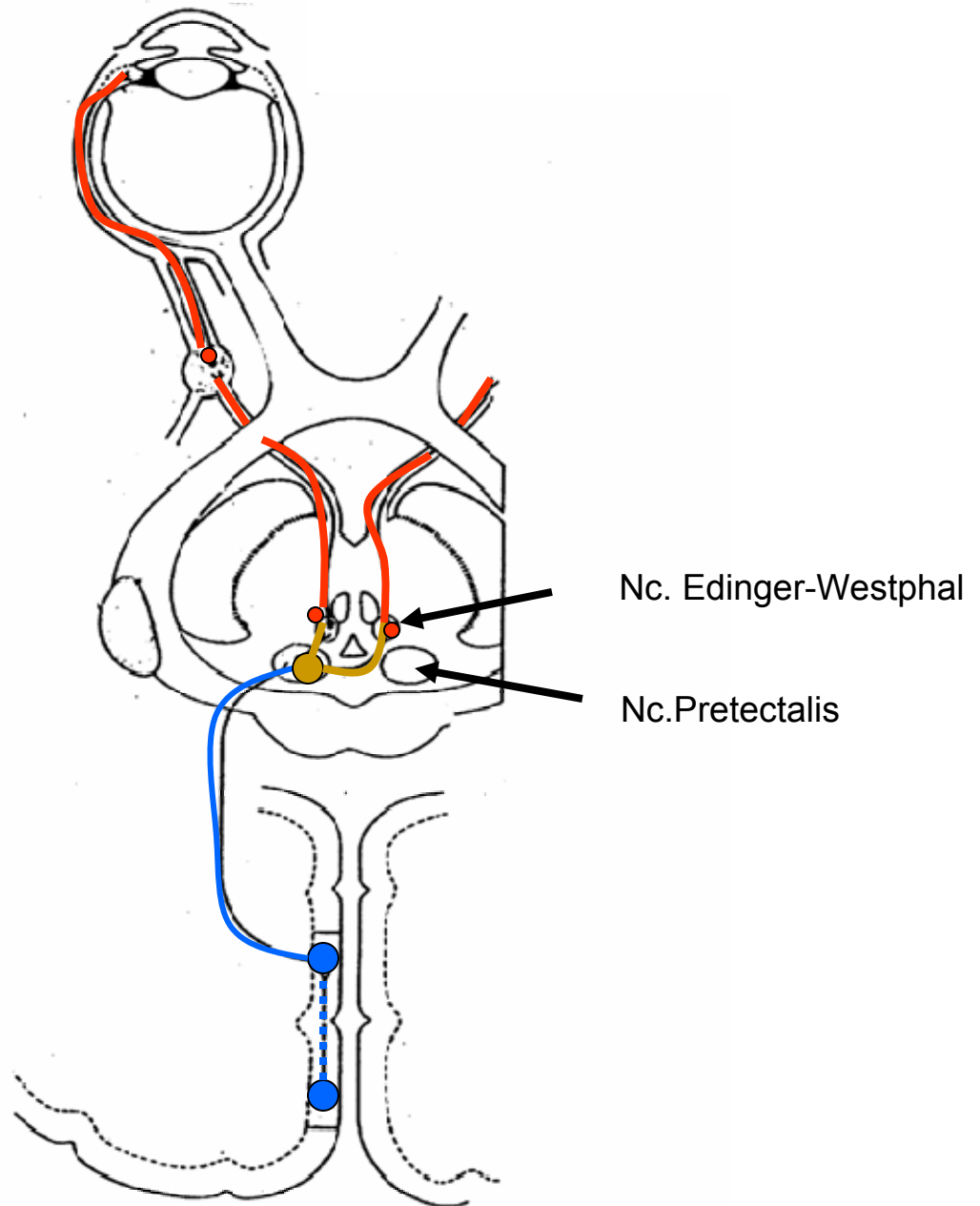
RELAKSACIJA CILIJARNOG MIŠIĆA,
ZATEZANJE LIGAMENATA,
SOČIVO JE TANKO - POSMATRANJE
U DALJINU

Refleks akomodacije

Konvergencija bulbusa

Mioza

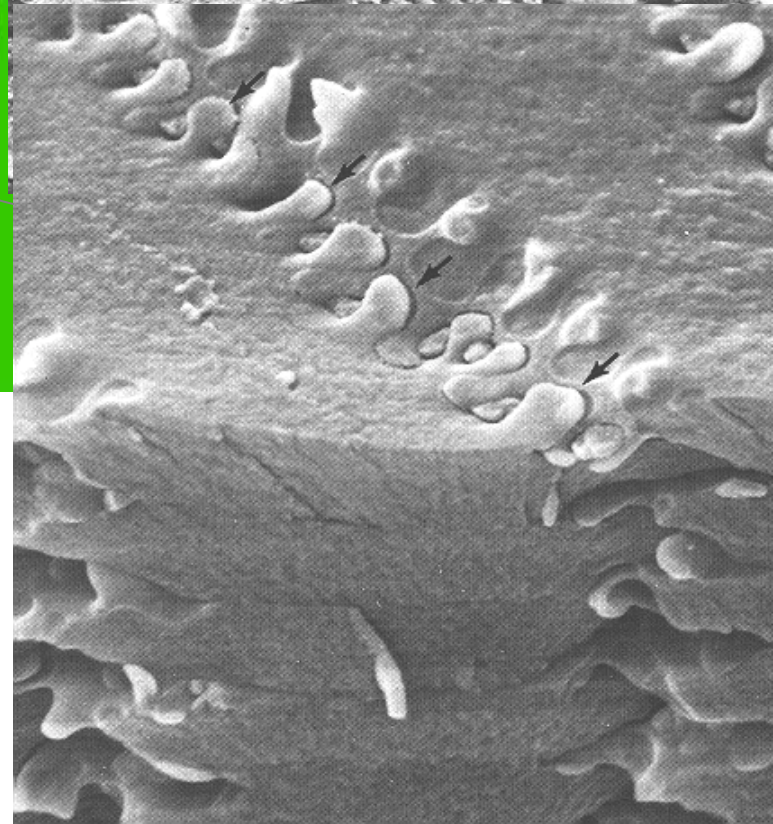
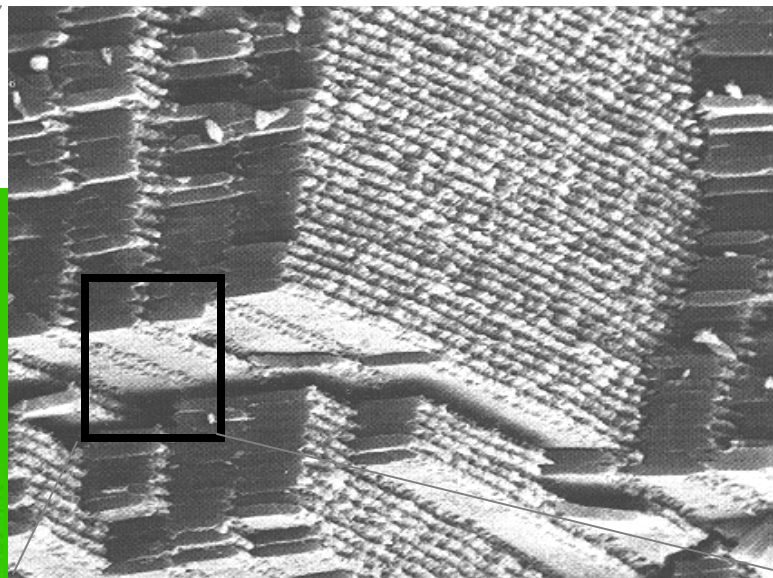
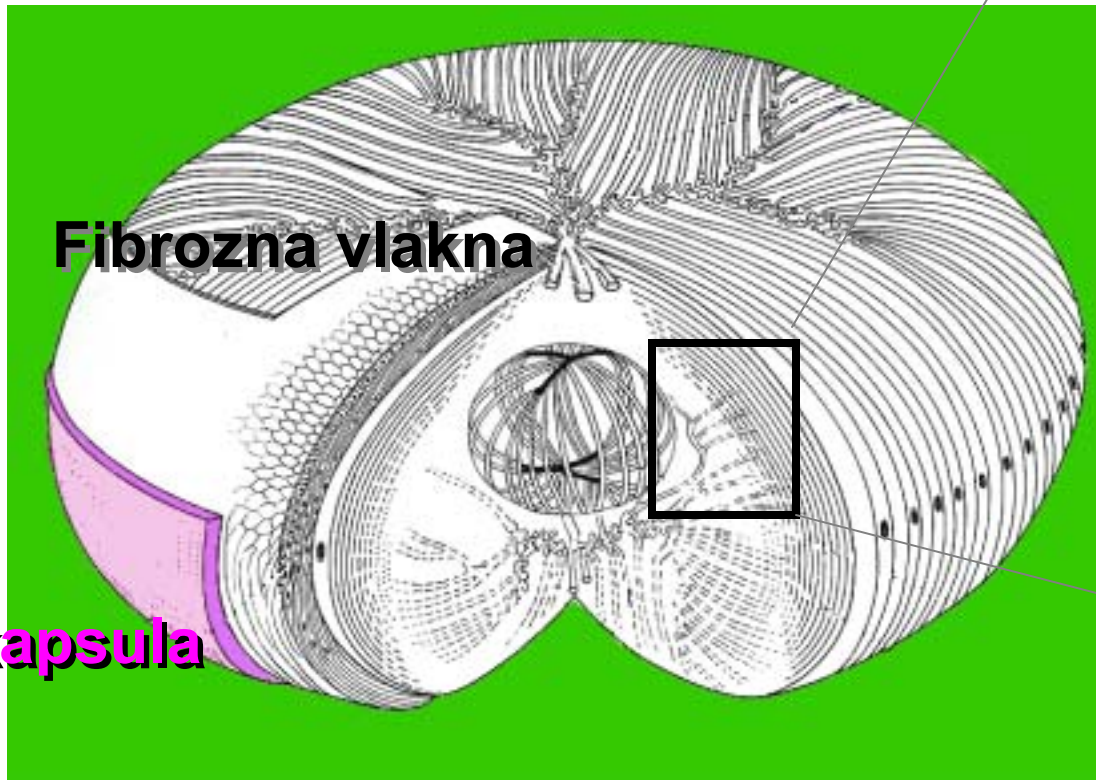
Zakrivljenost sočiva



Sočivo

Fibrozna vlakna

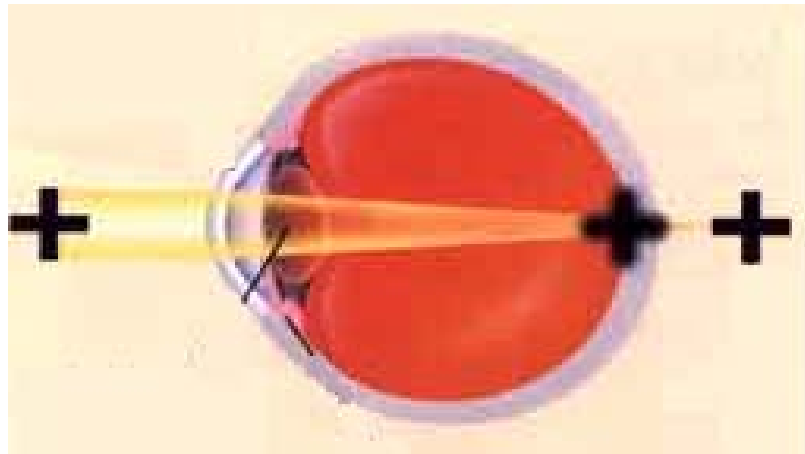
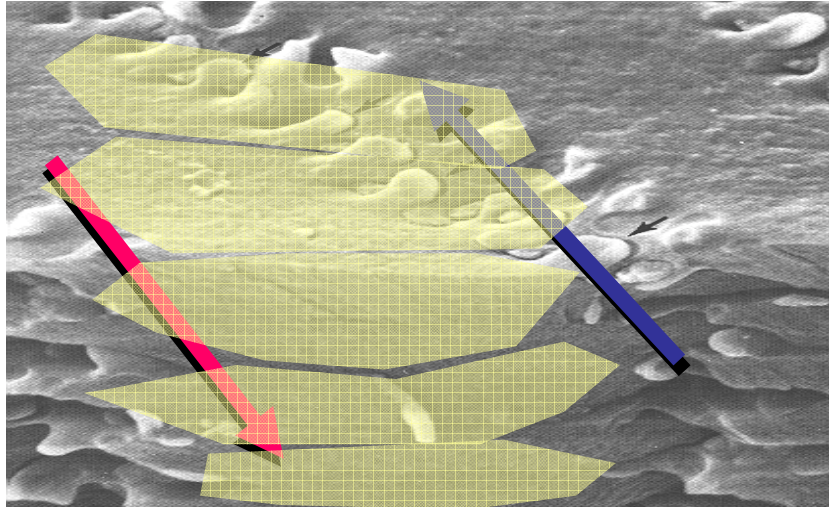
kapsula



Poremećaj akomodacije

Presbiopija

Pocinje posle 40 g



presbyatrics

556

presbyatrics (pres'be-at'riks) geriatrics.

presbycardia (pres'bī-kar'de-ah) impaired cardiac function attributed to aging, with senescent changes in the body and no evidence of other cause of heart disease.

presbycusis (-ku'sis) progressive, bilaterally symmetrical perceptive hearing loss occurring with age.

presbyope (pres'be-ōp) one who is presbyopic.

presbyophrenia (pres'be-o-fre'ne-ah) loss of memory, disorientation, and confabulation, occurring in old age.

presbyopia (-o'pe-ah) diminution of accommodation of the lens of the eye occurring normally with aging. **presbyop'ic**, adi.

ending sensitive to stimuli of ity.

pressosensitive (-sen'si-tiv) p

pressure (presh'ur) stress or stion, expansion, pull, thrust, (p., blood pressure in the arter p., the pressure exerted by about 15 pounds to the square **blood p.**, the pressure of the l of the arteries, dependent on heart action, elasticity of the e volume and viscosity of the *mum* or *systolic* pressure occ of the stroke output of the left *minimum* or *diastolic* late in

presbyatrics

556

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presbyopia (-o'pe-ah) diminution of accommodation of the lens of the eye occurring normally with aging. **presbyop'ic**, adi.

prescription (pre-skrip'shən) a written directive for the preparation and administration of a remedy; see also inscription, signature, subscription, and superscription.

presenile (-sen'ill) pertaining to a condition resembling senility, but occurring in early or middle life.

preservation (prez'er-vā'shən) the relative

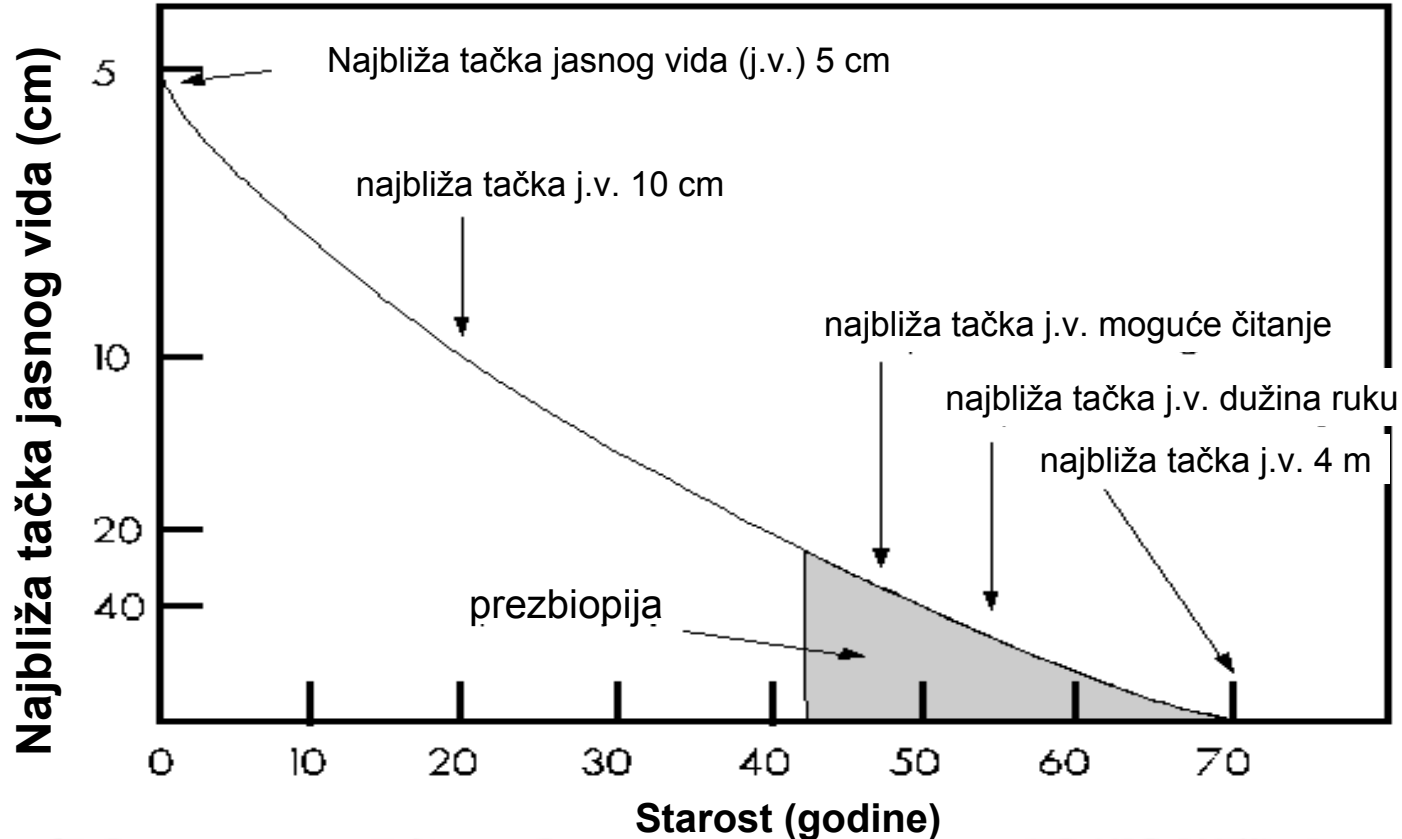
ending sensitive to stimuli of ity.

pressosensitive (-sen'si-tiv) p

pressure (presh'ur) stress or stion, expansion, pull, thrust, (p., blood pressure in the arter p., the pressure exerted by about 15 pounds to the square **blood p.**, the pressure of the l of the arteries, dependent on heart action, elasticity of the e volume and viscosity of the *mum* or *systolic* pressure occ of the stroke output of the left *minimum* or *diastolic* late in *isls*, *capillary p.*, *blood pres* *larics*, *cerebrospinal p.*, the size of the cerebrospinal 100-120 mm. as measured by *intracranial p.*, *pressure of dal fluid*, *intravascular p.*, the against the outer coats by 10 *eyeball*, *negative p.*, *pressur the atmosphere*, *astrotic m.*

Oči se više ne mogu prilagoditi, gledanju na blizinu i na daljinu (bifokalne naočare)

Akomodaciona sposobnost sočiva



Prezbiopija - Starenjem, dolazi do denaturacije proteina sočiva i elastičnost se smanjuje kao i akomodaciona sposobnost
- 14 D kod dece, 1-3.5 D (45-50 g), 0 D 70 g.

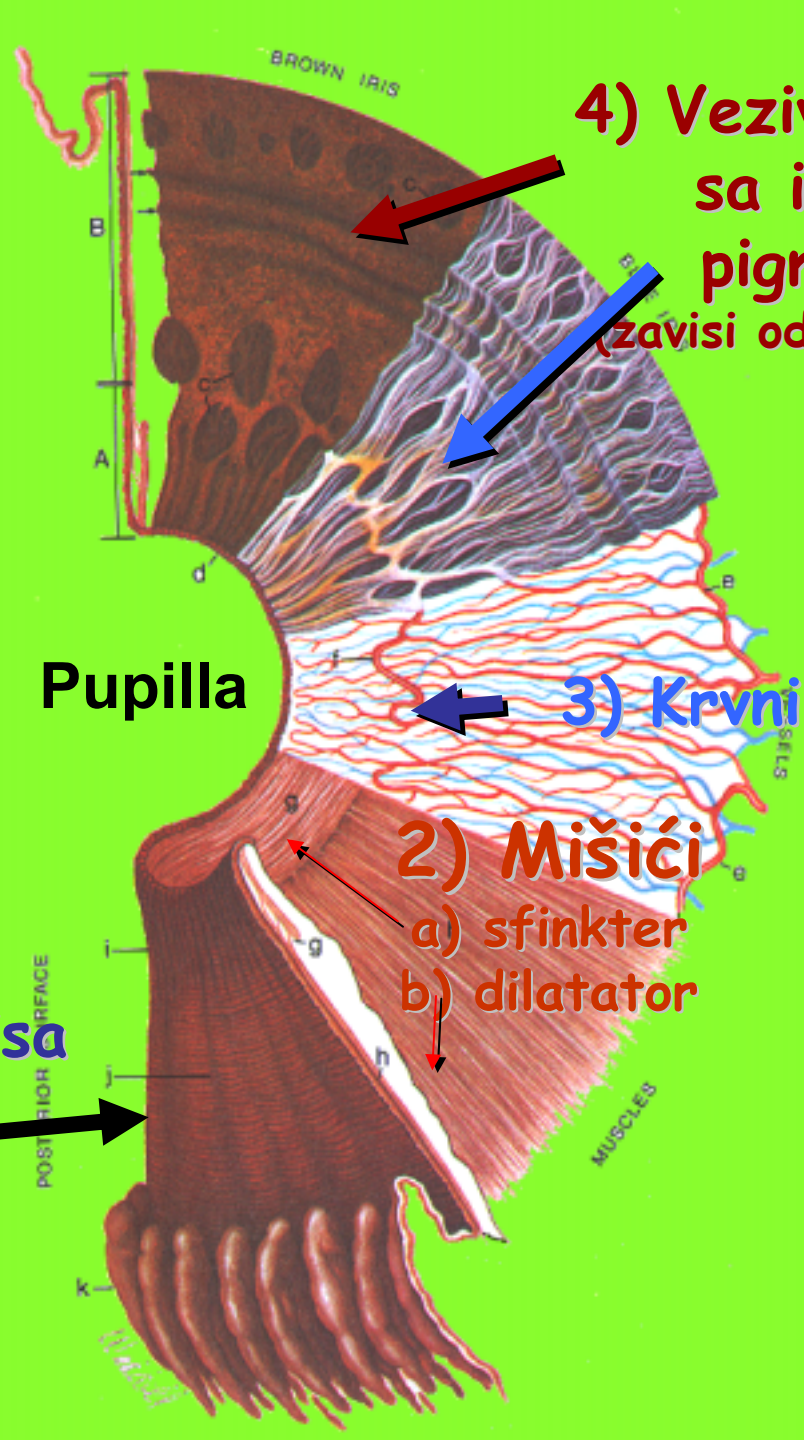
Iris

slojevi irisa

(pozadi-napred)

1) Zadnja površina irisa

pigmentne ćelije
Sprečavaju ulazak
svetlosti

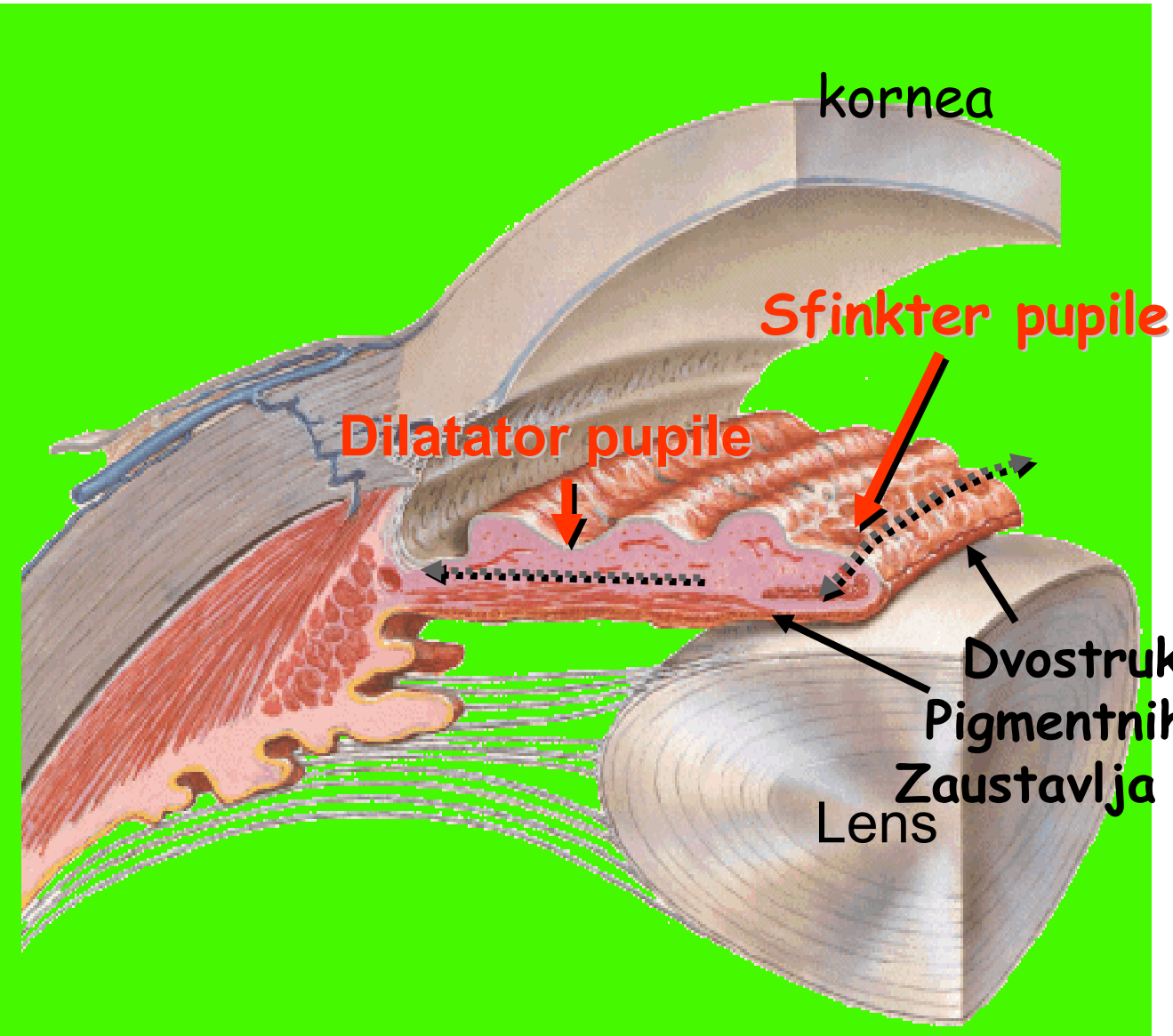


4) Vezivno tkivo
sa ili bez
pigmenta
(zavisi od boje očiju)

3) Krvni sudovi

2) Mišići
a) sfinkter
b) dilatator

Uloge irisa



Sfinkter pupile



Parasimpatikus
Intenzivna svetlost

Dilatator pupile



Simpatikus
Prigušena svetlost

Refleks zenice na svetlost

DIREKTNA REAKCIJA

m. Sfincter pupille

Ganglion ciliare

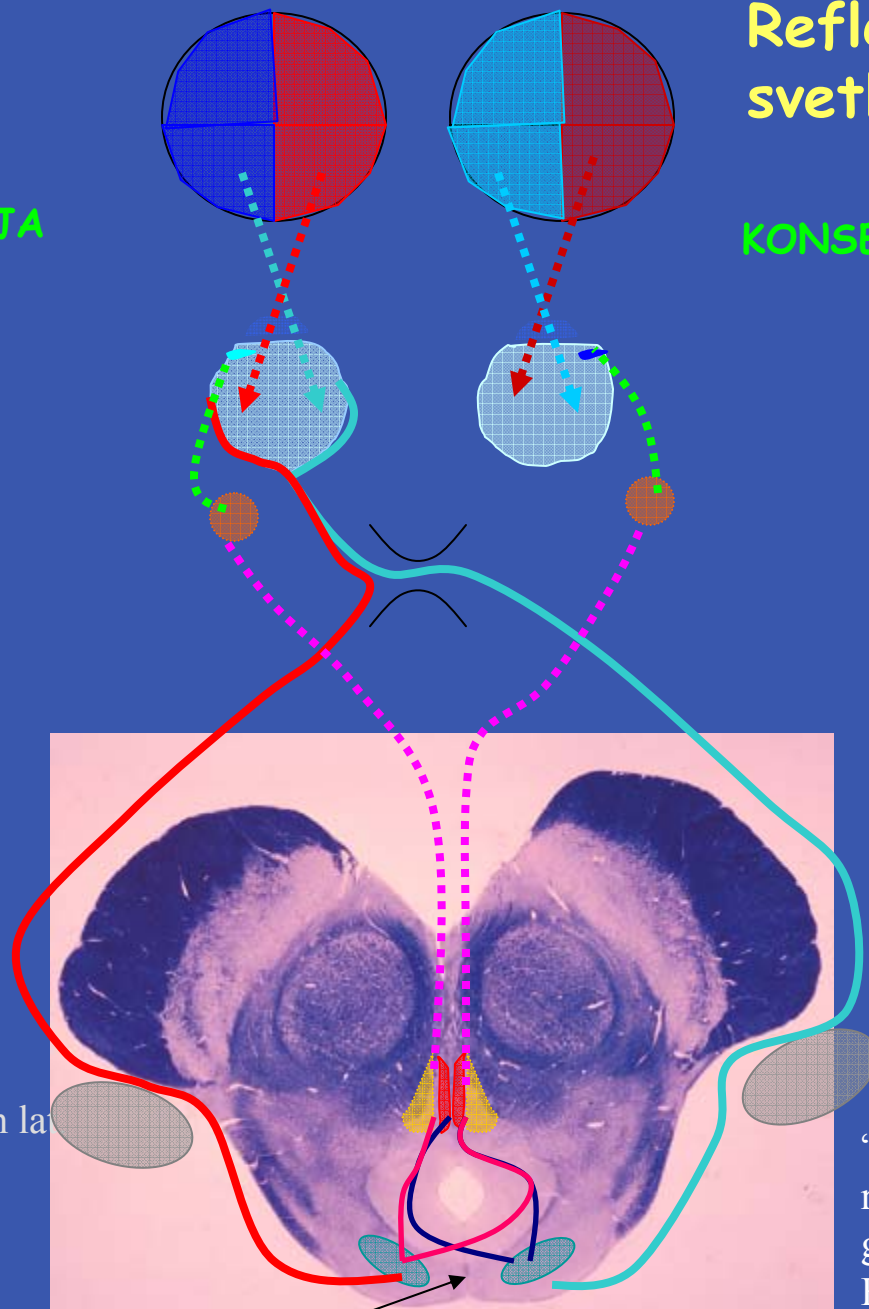
Nc. Edinger-Westphal

Corpus geniculatum lat.

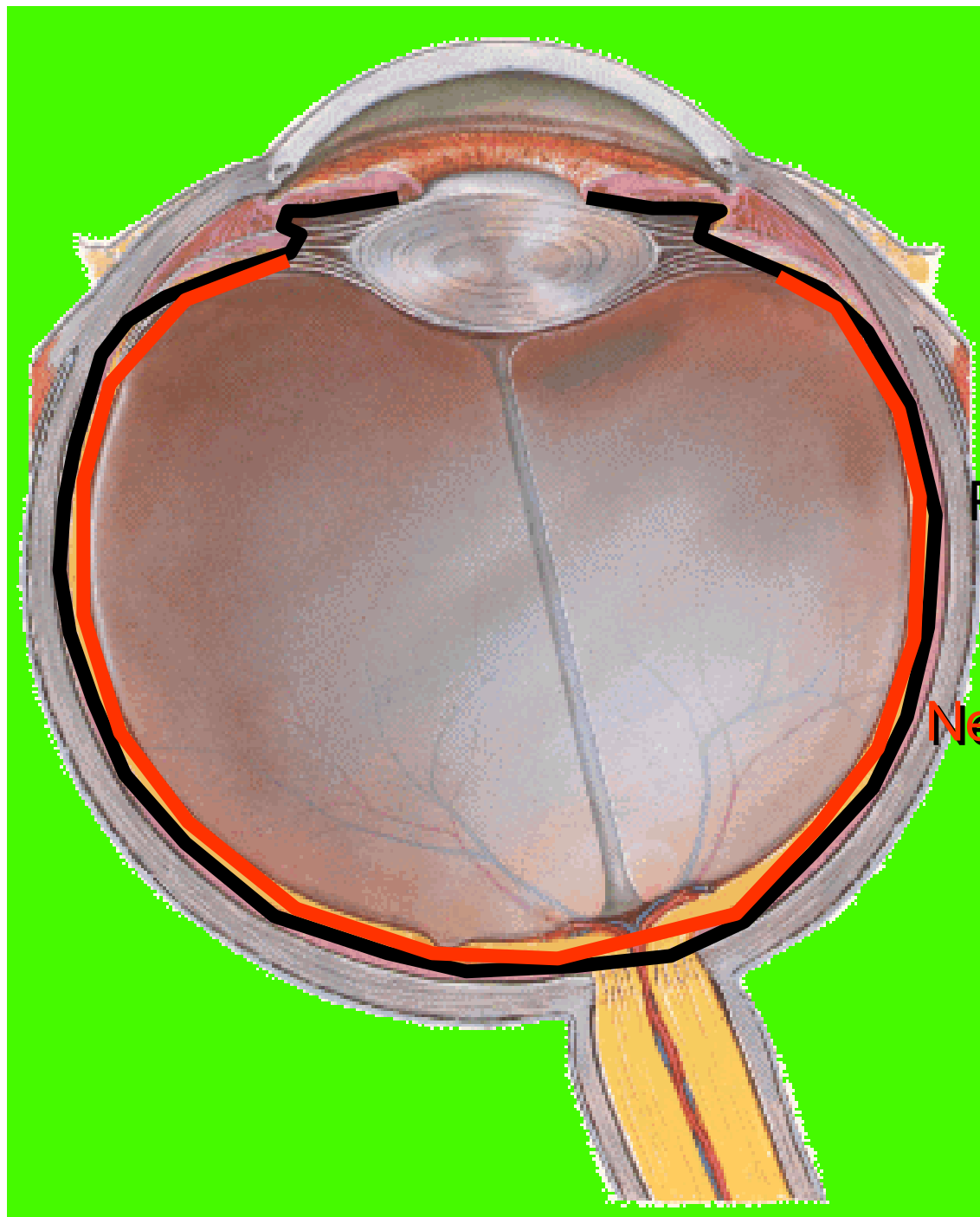
Nc. Pretectalis

Commissure posterior

KONSENZUALNA REKACIJA



“extrageniculatni put” vlakna iz retine koja zaobilaze corpus geniculatum lat. I prolaze kroz Brachium coliculli superior



Pigmentni
epitel

Neural. Retina

Fovea centralis,
prečnika 0,3 mm,
sastoji se isključivo
od čepića
koji imaju posebnu
strukturu,
koja im omogućava
da raspoznaju
detalje u
vidnoj slici,

Oštar i precizan vid

vene

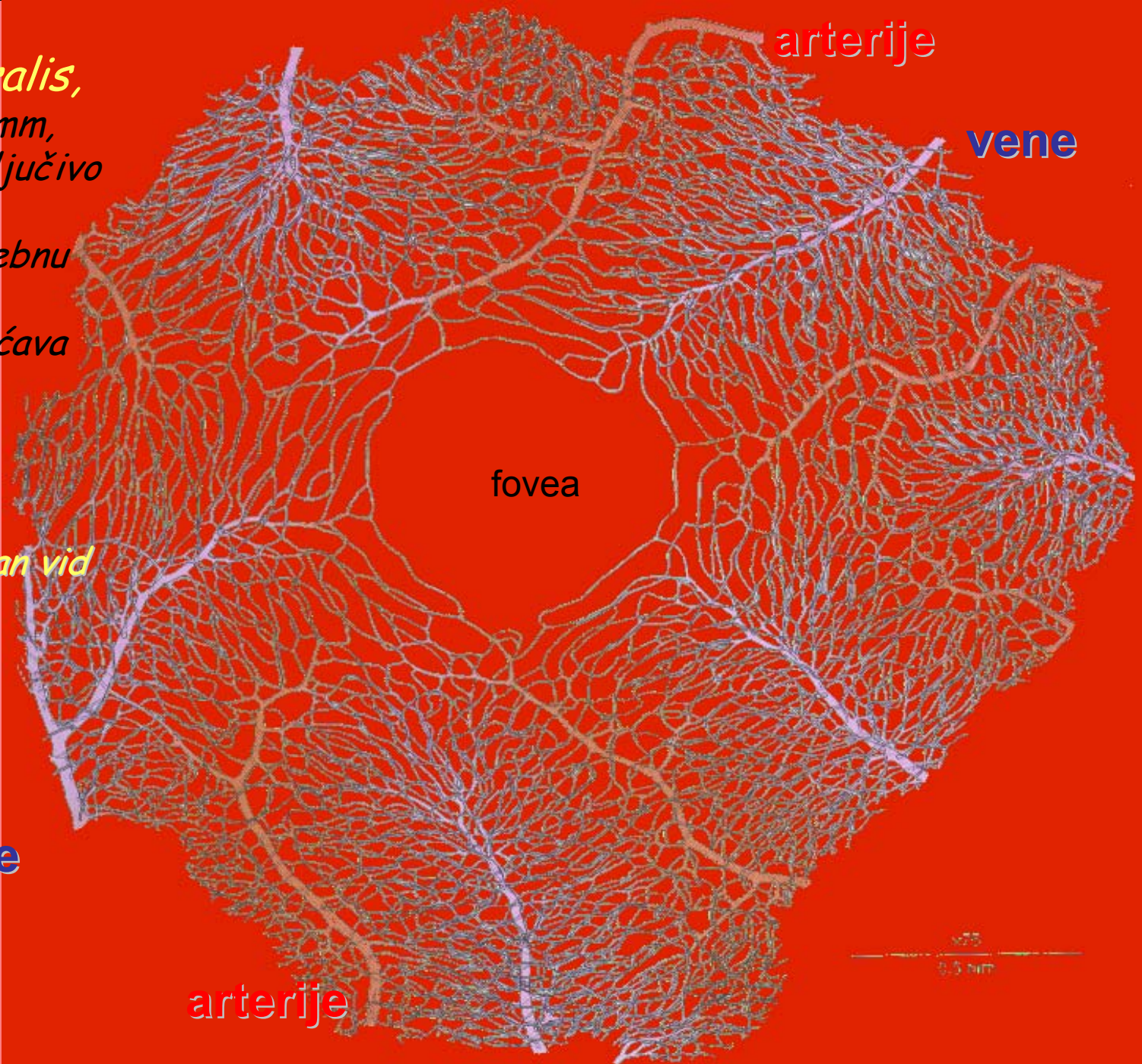
arterije

arterije

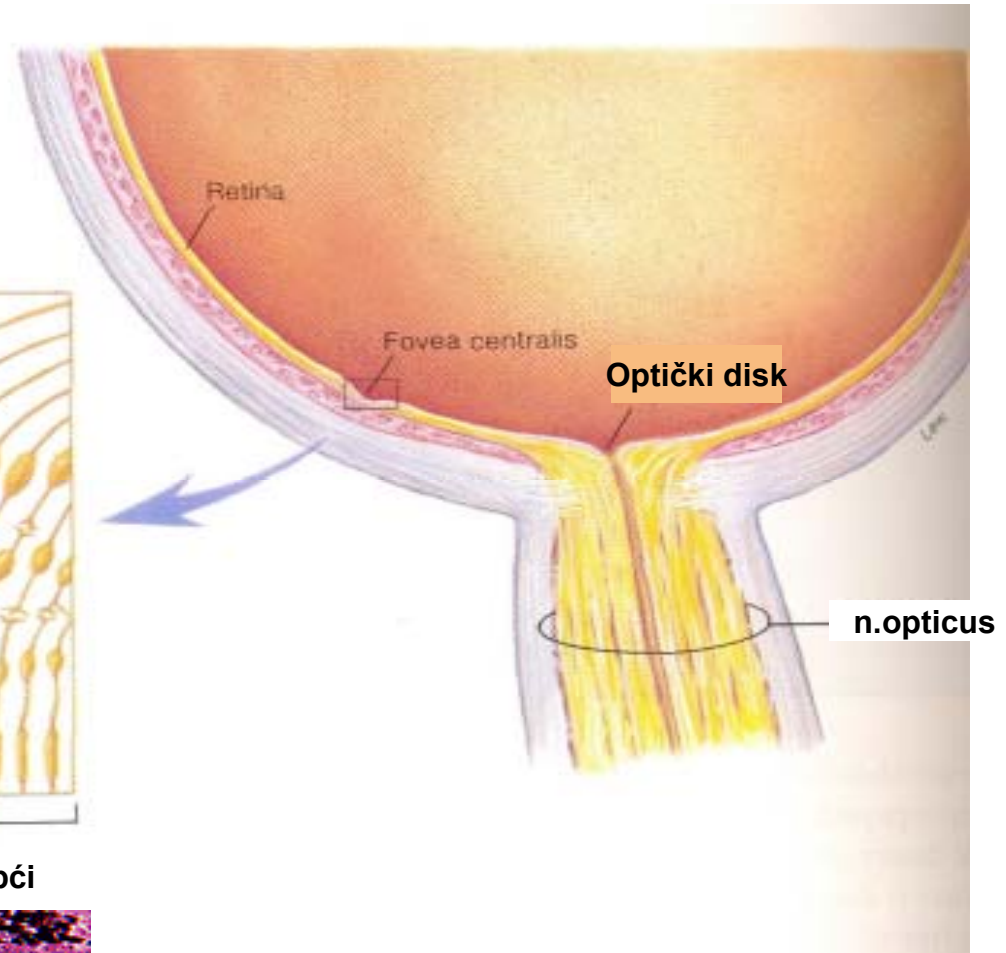
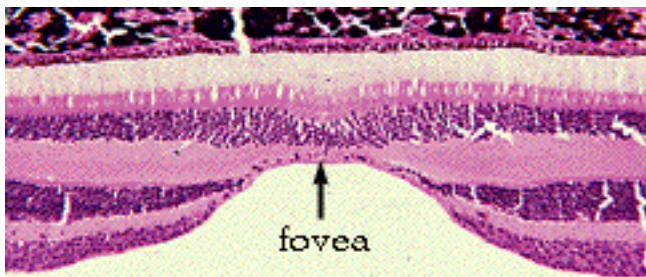
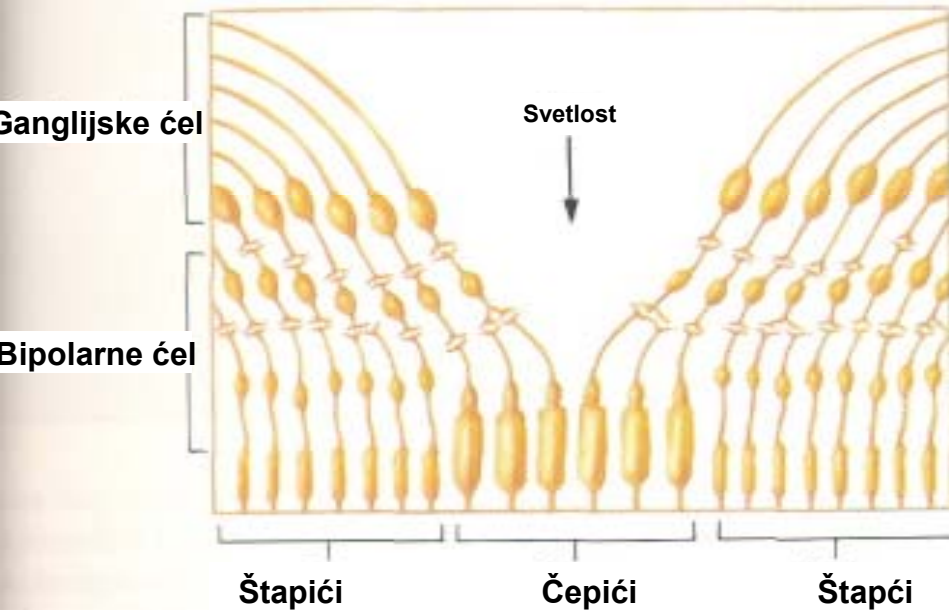
vene

fovea

0,5 mm

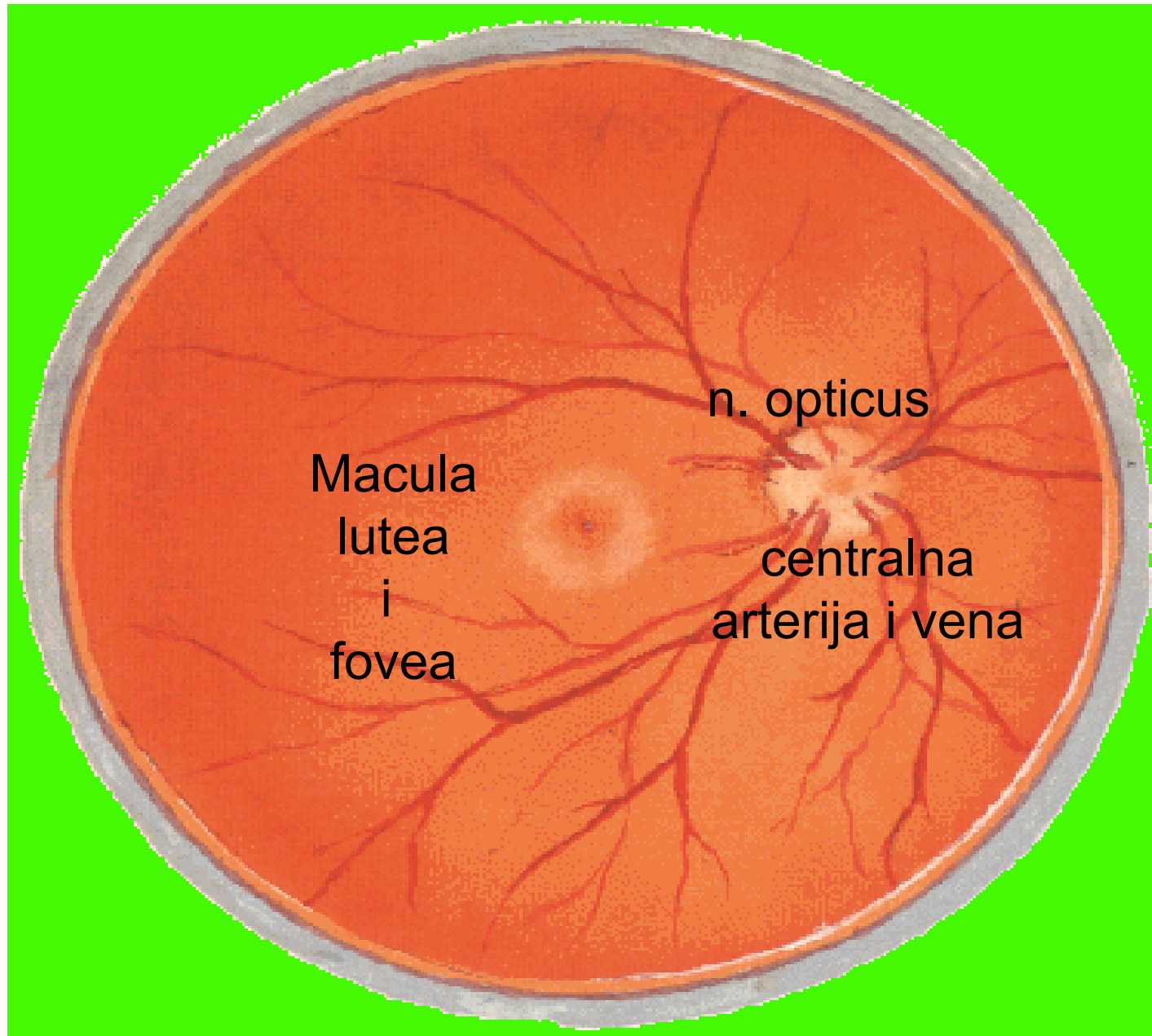


U ***fovei centralis***
postoje samo tanki
čepići, njih oko 35 000,
a štapčića uopšte nema



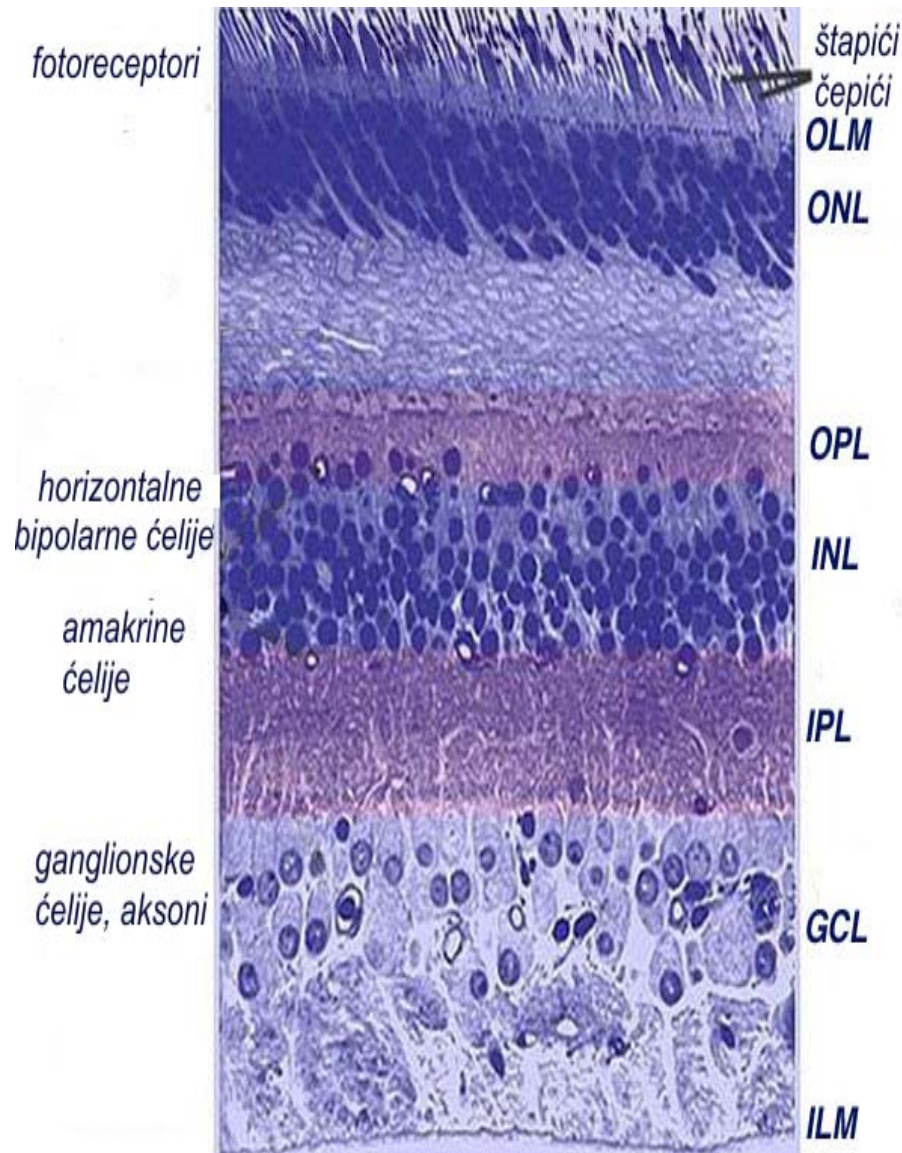
*Br. nervnih vlakana koji
vodi od foveje
je jednak br. čepića*

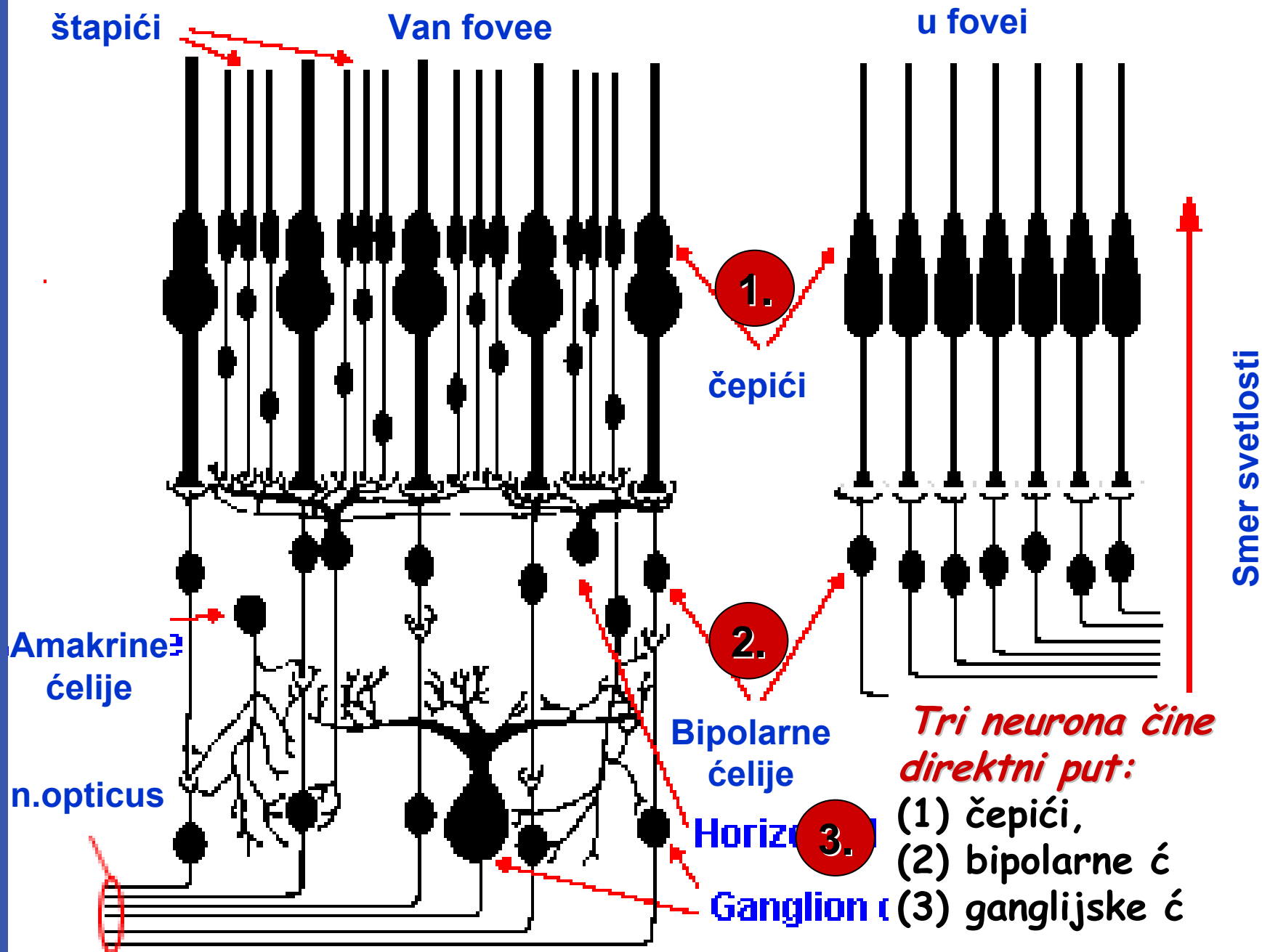
Očno dno



Neuralna funkcija retine

1. **štapići i čepići**,
2. **Horizontalne ćelije**, prenose signale horizontalno u spoljašnjem pleksiformnom sloju sa štapića i čepića na bipolarne ćelije
3. **Bipolarne ćelije**, prenose signale vertikalno sa štapića, čepića i horizontalnih ćelija, do ganglijskim i amakrinim ćelijama
4. **Amakrine ćelije**, prenose signale direktno sa bipolarnih ćelija na ganglijske ćelije, bilo horizontalno unutar unutrašnjeg pleksiformnog sloja između aksona bipolarnih ćelija
5. **Ganglijske ćelije**, prenose izlazne signale od retine kroz optički nerv do mozga

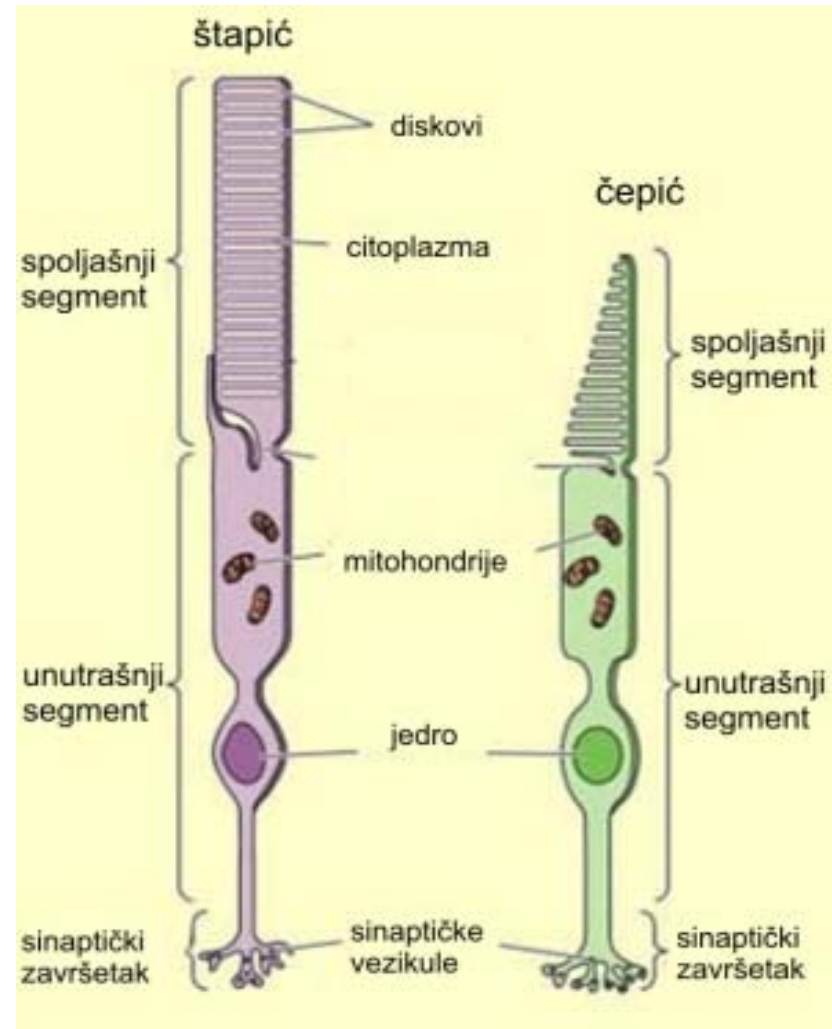




Fotoreceptori

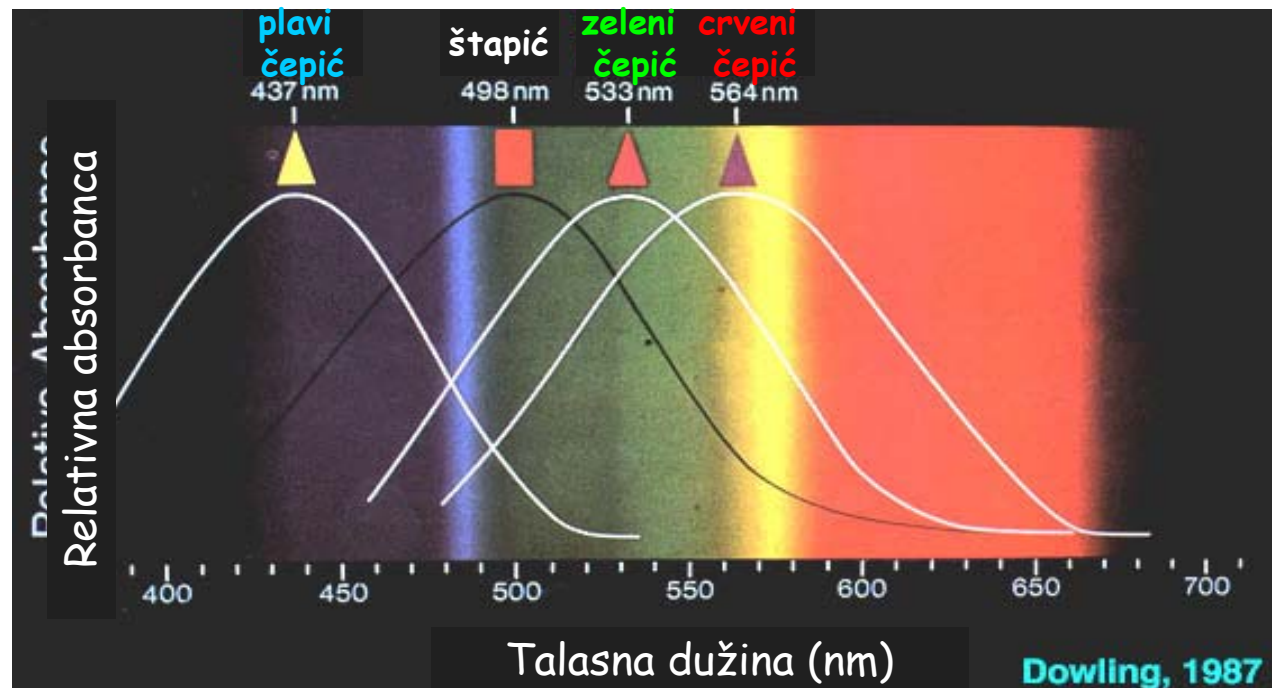
čepići i štapići razlikuju se po:

- Obliku



čepići i štapići razlikuju se po:

- Obliku
- Osetljivosti

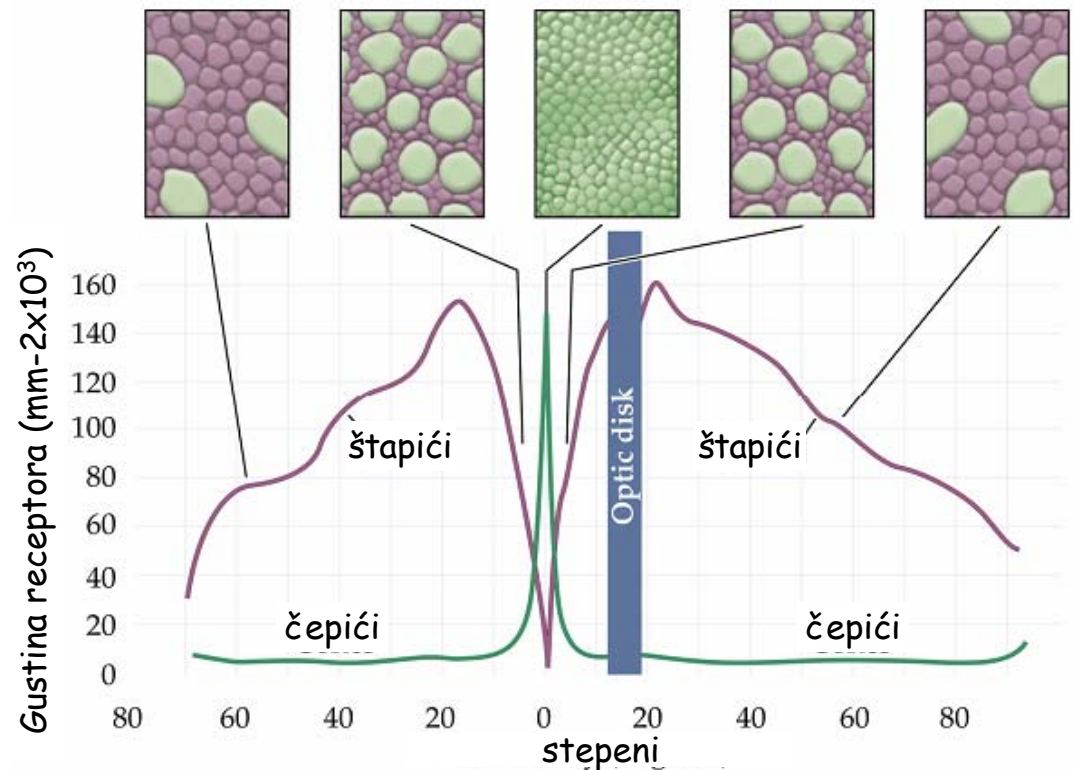


Fotoreceptori

čepići i štapići razlikuju se po:

- Obliku
- Osetljivosti
- Distribuciji

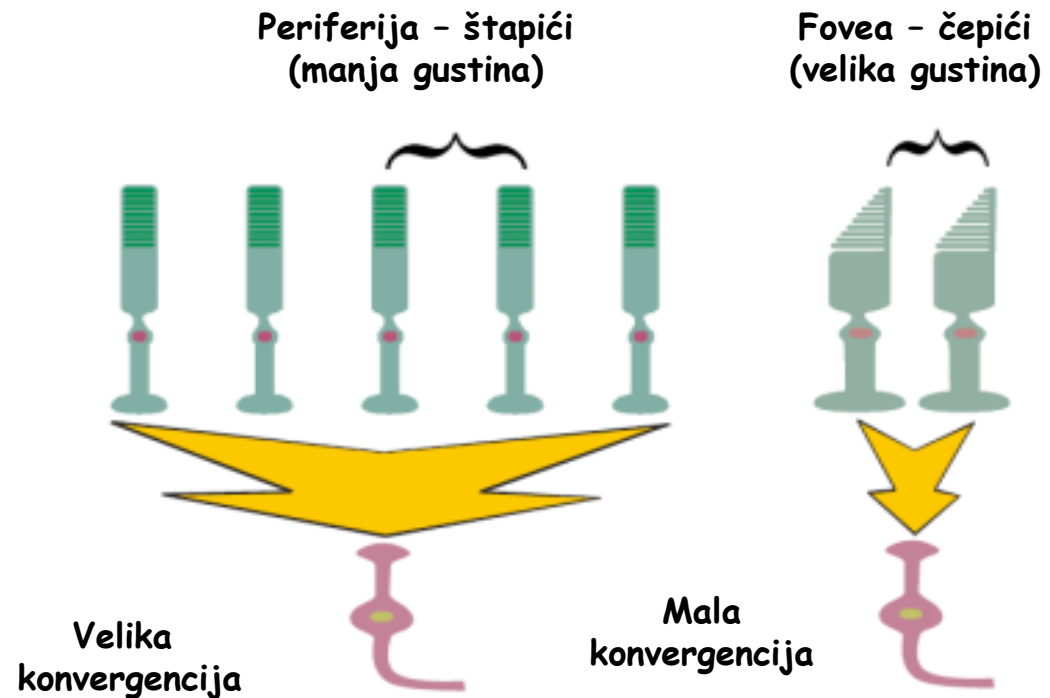
Distribucija čepića i štapića u retini



Fotoreceptori

čepići i štapići razlikuju
se po:

- Obliku
- Osetljivosti
- Distribuciji
- Konvergenciji



Fotoreceptori

čepići i štapići razlikuju se po:

- Obliku
- Osetljivosti
- Distribuciji
- Konvergenciji
- **Funkciji**

štapići, odgovorni za
crno - belo i
gledanje u mraku
Skotopski vid

čepići, zapažaju boje
3 000 000 čepića
Fotopski vid

Štapići i čepići

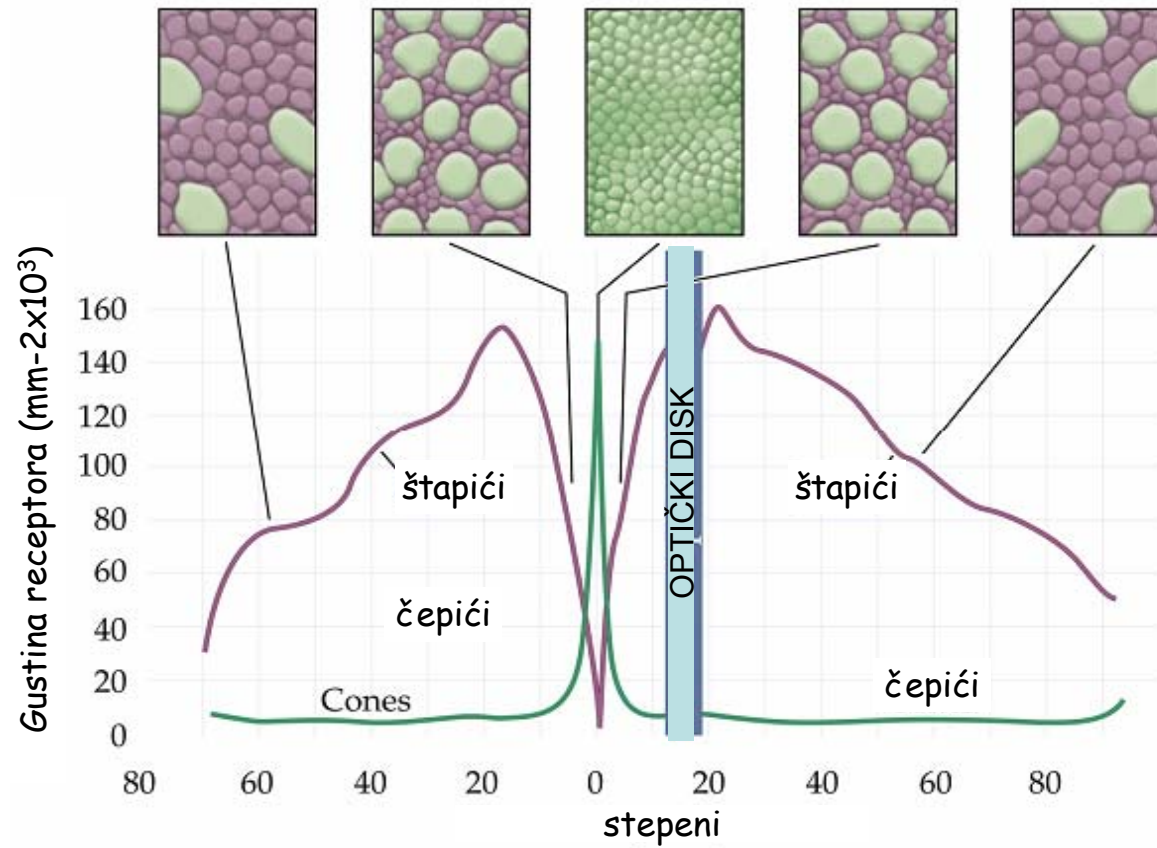
Štapići

- Velika osetljivost, skotopski vid
 - Imaju više fotopigmenta, bolja apsorpcija svetlosti
 - Velika amplifikacija, detekcija 1 fotona
 - Saturacija pri dnevnoj svetlosti
- Slaba temporalna rezolucija
 - Spor odgovor, dugačko vreme integracije
- Osetljivi na indirektnu svetlost
- Mala preciznost
 - Velika konvergencija
 - Nisu prisutni u fovei centralis
- Ahromatski

Čepići

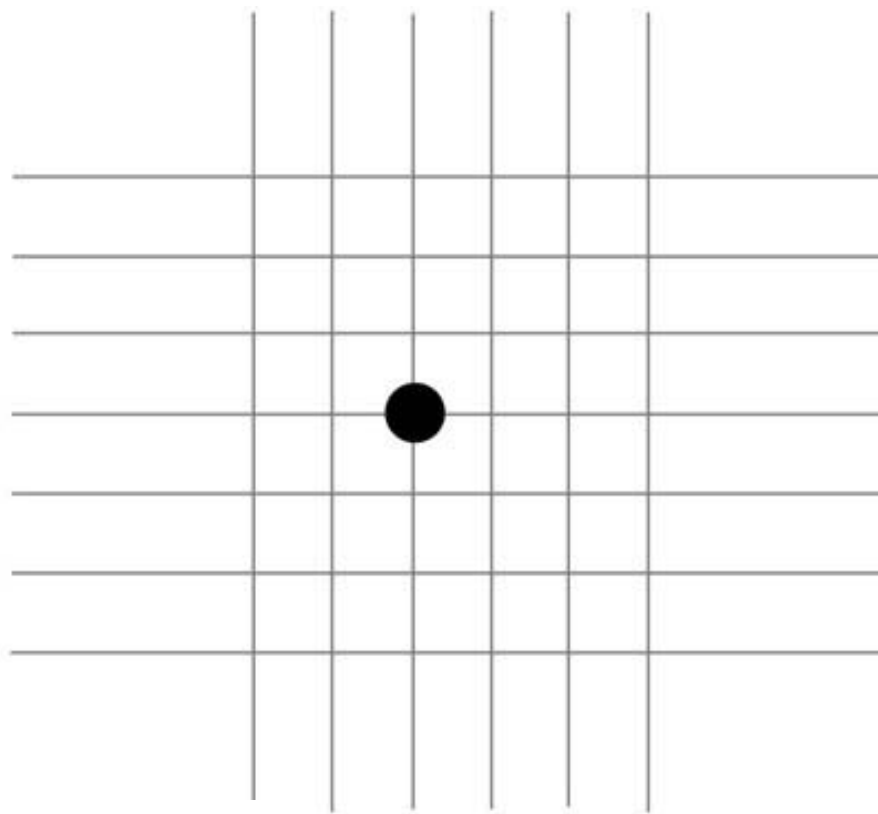
- Mala osetljivost, fotopski vid
 - Manje fotopigmenta
 - Manja amplifikacija
 - Saturacija pri intenzivnoj svetlosti
- Dobra temporalna rezolucija
 - Brz odgovor, kratko vreme integracije
- Najosetljiviji na direktnu svetlost
- Velika preciznost
 - Mala konvergencija
 - Prisutni u fovei centralis
- Hromatski
 - 3 tipa čepića, svaki sa različitim pigmentom osetljivim na različite delove vidljivog spektra (opsini čepića).

Slepa mrlja



Slepa mrlja - Mariotov ogled

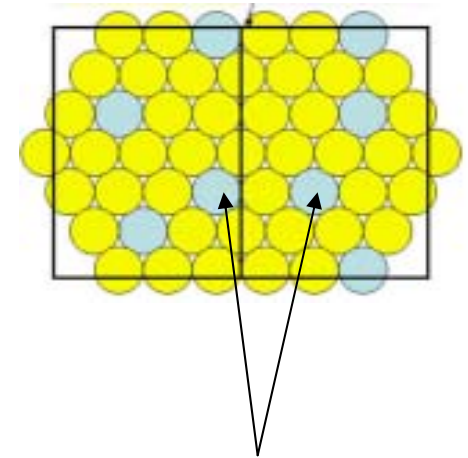
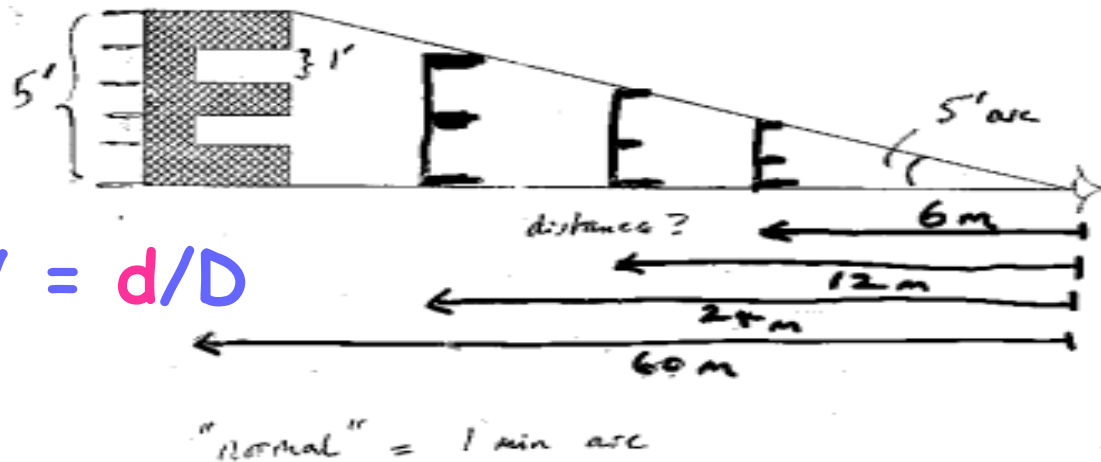
X



Oštrina vida = Visus

Ispituje se funkcija Fovee

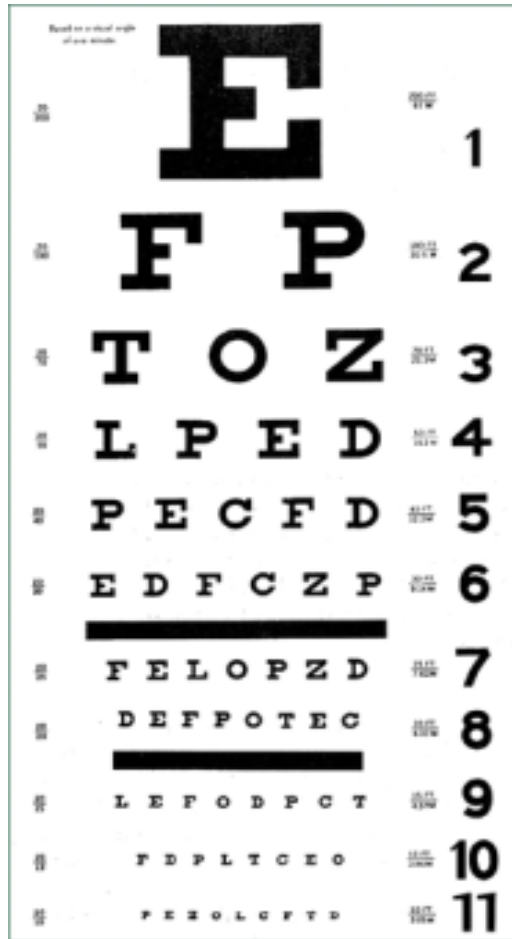
Spособnost oka da vidi odvojeno 2 tačke koje zaklapaju ugao 1 min



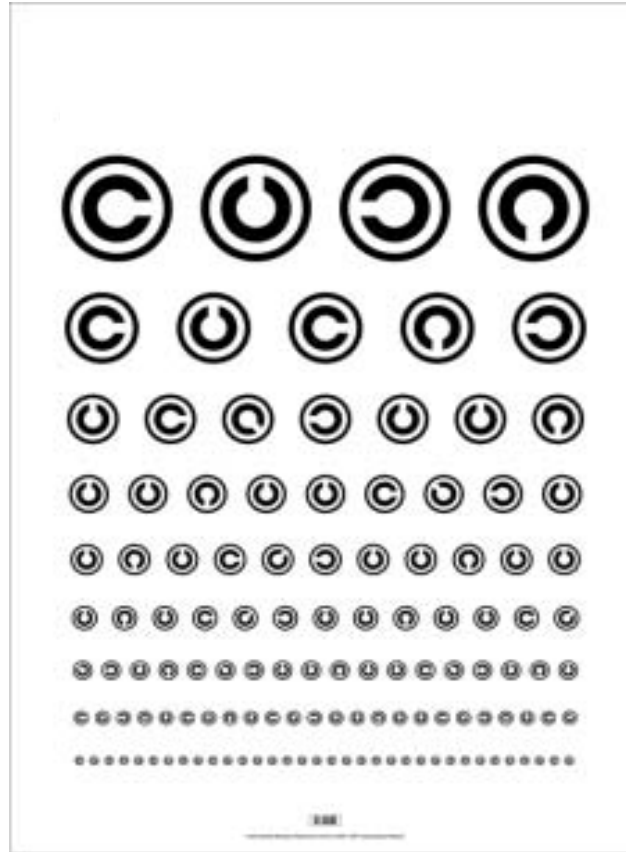
- d – rastojanje sa kog čita
- D – rastojanje na kom slovo zaklapa ugao 5min

Odredjivanje oštine vida - optotip

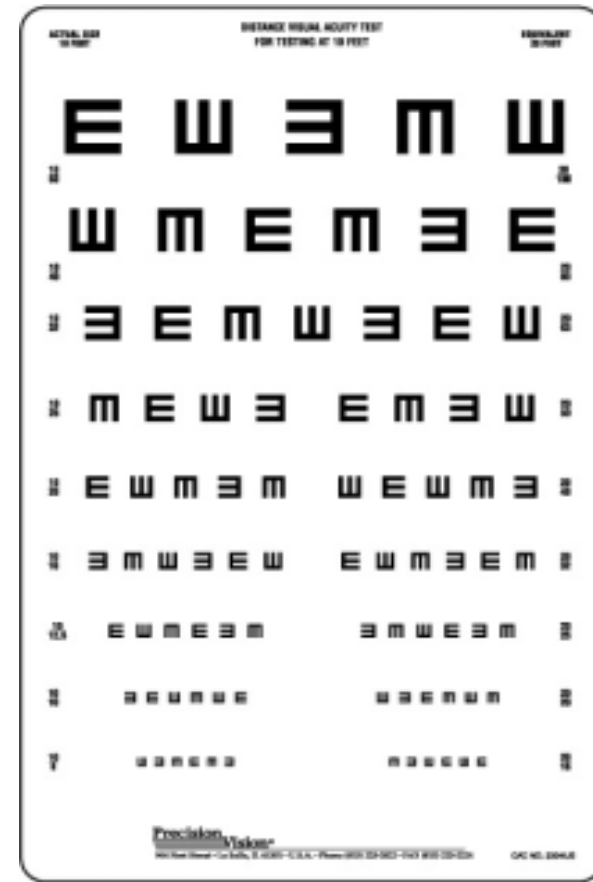
Uz prethodno korigovanu refrakcionu anomaliju!!



Snellen-optotip
tablice



Landolt-optotip
tablice



Tumbling-optotip/
Pflüger optotip
tablice

Snellen-ove tablice

64

$\frac{20}{800}$

734

$\frac{20}{400}$

3986 ㄣ ㄣ

$\frac{20}{200}$



Slepi
20/200

5237

ㄣ ㄣ ㄣ

↑ → ↓

$\frac{20}{100}$

7943

ㄣ ㄣ ㄣ

→ ↑ ←

$\frac{20}{70}$



Smanjen visus
20/70

89748

ㄣ ㄣ ㄣ

← ↑ →

$\frac{20}{50}$

690283

ㄣ ㄣ ㄣ

↓ ↑ ↑

$\frac{20}{40}$

2483761

ㄣ ㄣ ㄣ

↓ ↓ ↓

$\frac{20}{30}$

92786584

ㄣ ㄣ ㄣ

→ ↑ ↑

$\frac{20}{25}$

85940372

ㄣ ㄣ ㄣ

← → ↑

$\frac{20}{20}$



Normalno"
20/20

Visus

Snellen (metri)	Snellen (Feet)	Visus	Ugao (1')	Ocuvanost vida %	Gubitak vida %
6/6	20/20	1.0	1.0	100	0.0
6/9	20/30	0.7	1.5	91.4	8.6
6/12	20/40	0.5	2.0	83.6	16.4
6/18	20/60	0.3	3.0	69.9	30.1
6/24	20/80	0.25	4.0	58.5	41.5
6/60	20/200	0.1	10.0	20.0	80.0

RANGE OF VISION

BEZ
MESEČINE

MESEČINA
PUN MESEC

RANI
SUMRAK

VEŠTAČKO
SVETLO

SUNČANO

MEZOPSKI VID

SKOTOPSKI VID

FOTOPSKI VID

ČEPIĆI

ŠTAPIĆI

1E-06 1E-04 1E-02 1E+00 1E+02 1E+04 1E+06

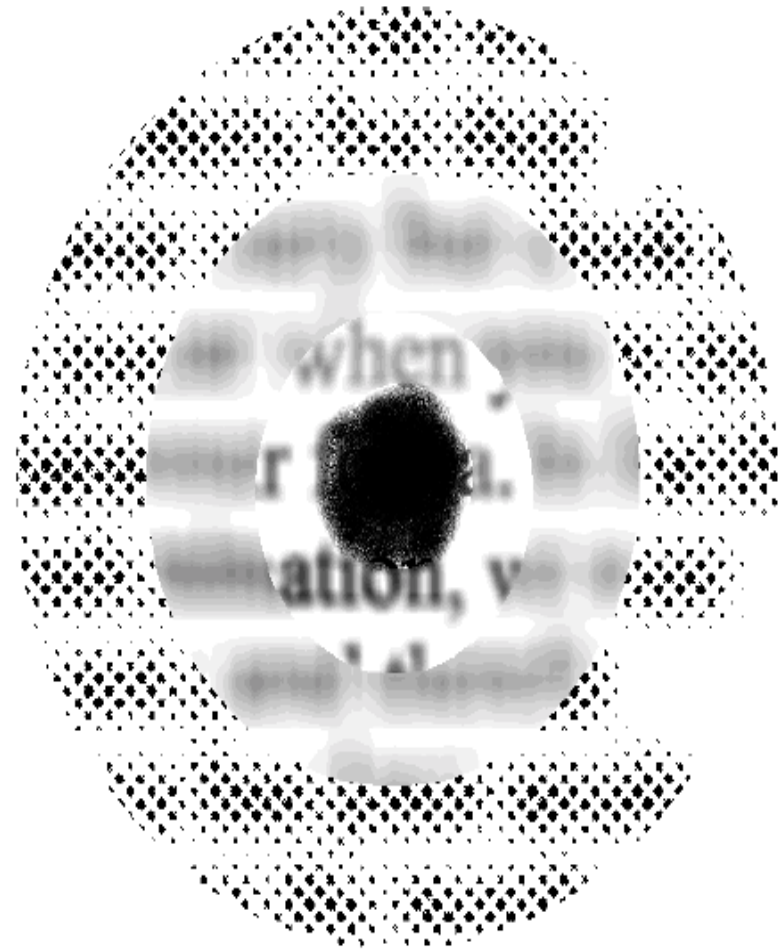
Log luminiscencije (Cd/m²)

Dan - fotopski vid



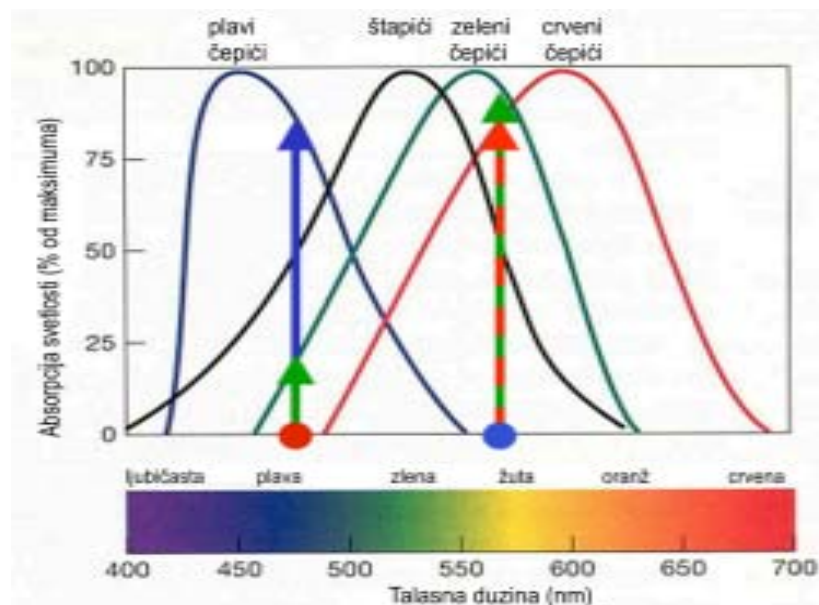
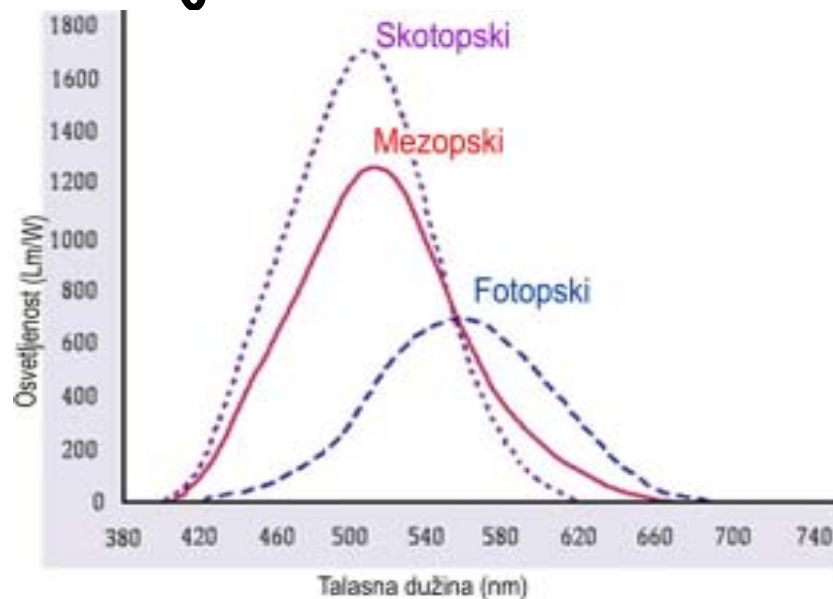
CENTRALNA FOVEA VIDI
DETALJE I BOJE
Čepići $> 0.03 \text{ cd/m}^2$

Noć - skotopski vid



PERIFERIJA VIDI
CRNO&BELO
FOVEA JE SLEPA
Štapići $< 0.03 \text{ cd/m}^2$

Mezopski vid-Purkinjeov efekt



Apsorpcioni maksimum rodopsina 500 nm

Noćno slepilo (gubitak štapića)



Ahromazija (ahromatopsija) (gubitak čepića)

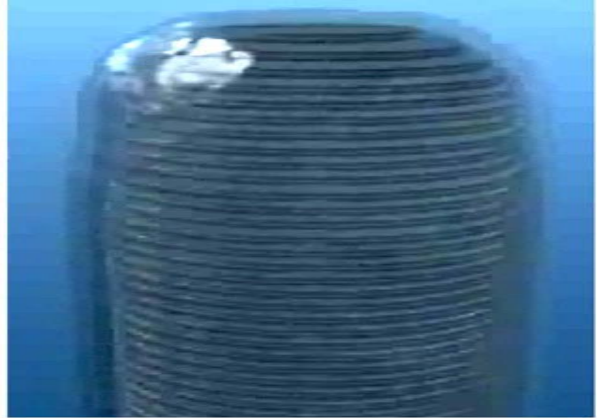
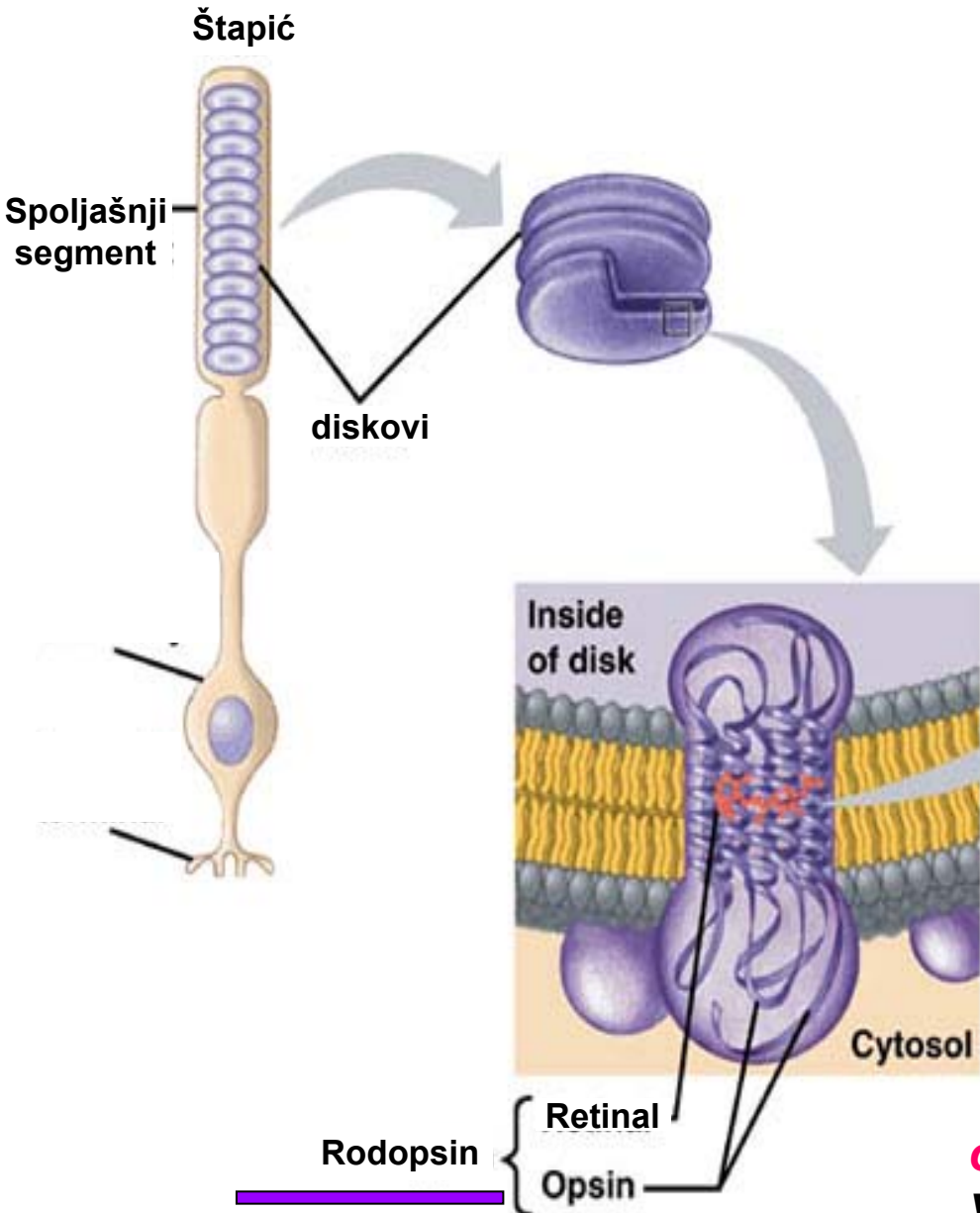
A



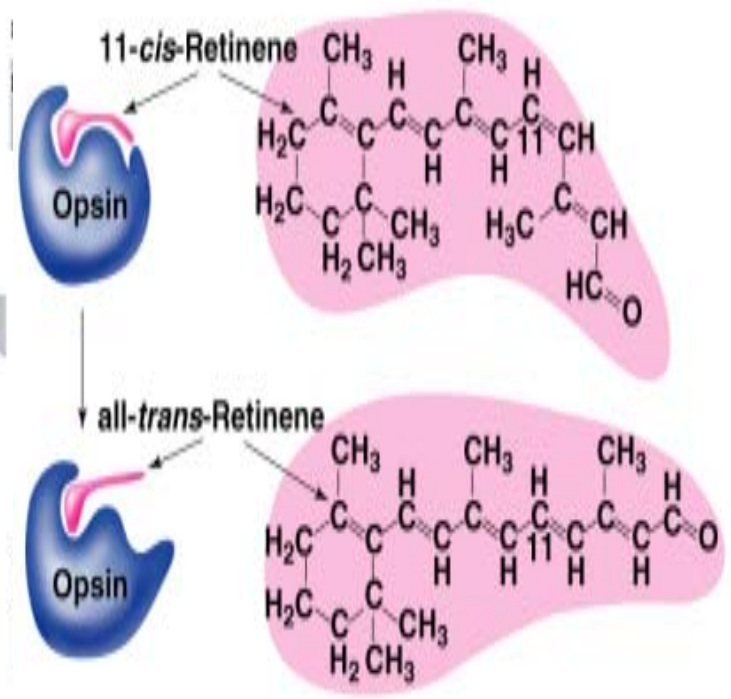
B



Aktivacija rodopsina



Photoreceptor outer segments and the disc structures (From Carlos Rozas, CanalWeb, Chile).

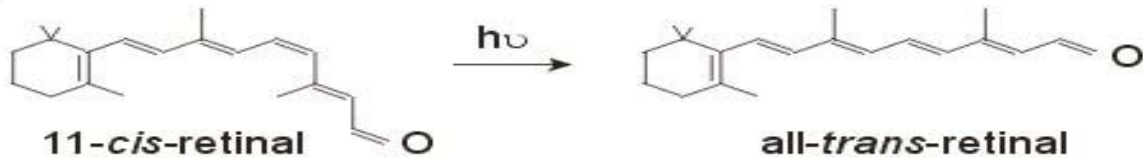


opsin čepića
Vs.
Opsin štapića

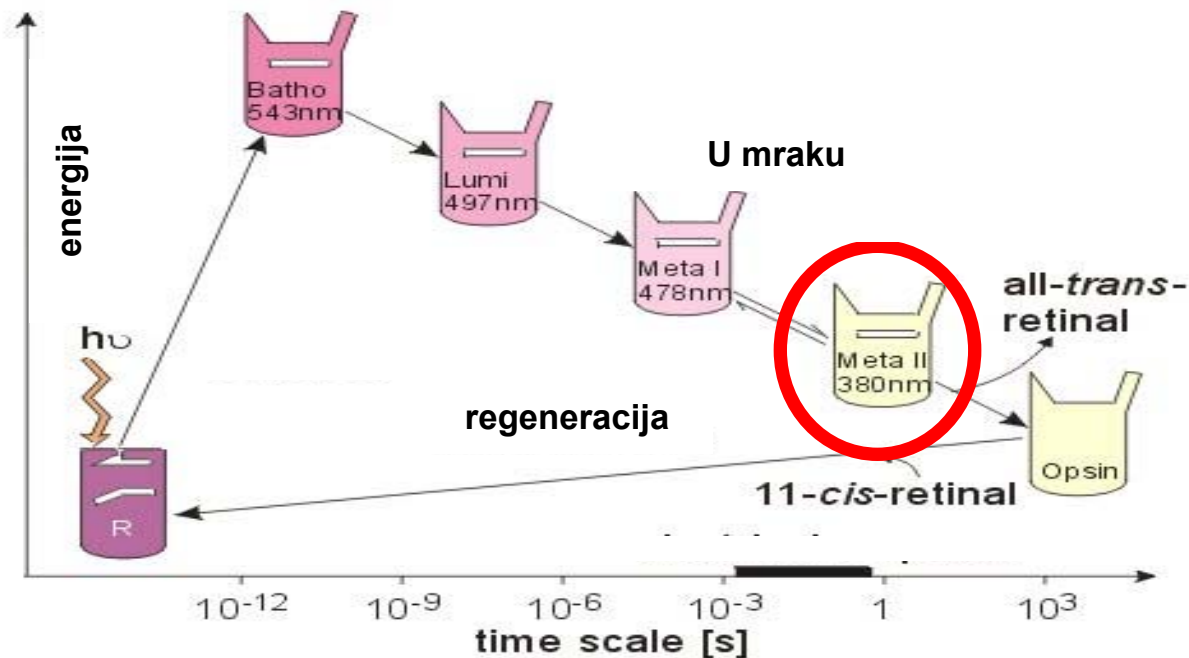
Aktivacija rodopsina

(George Wald, 1935)

A)

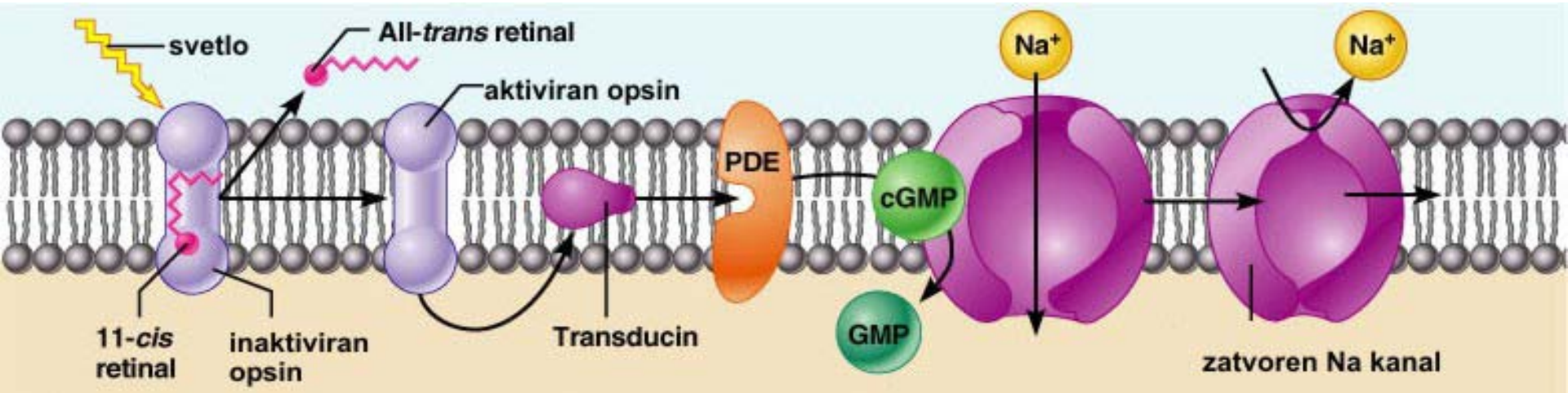


B)



metarodopsina II,
koji je aktivan
oblik rodopsina,

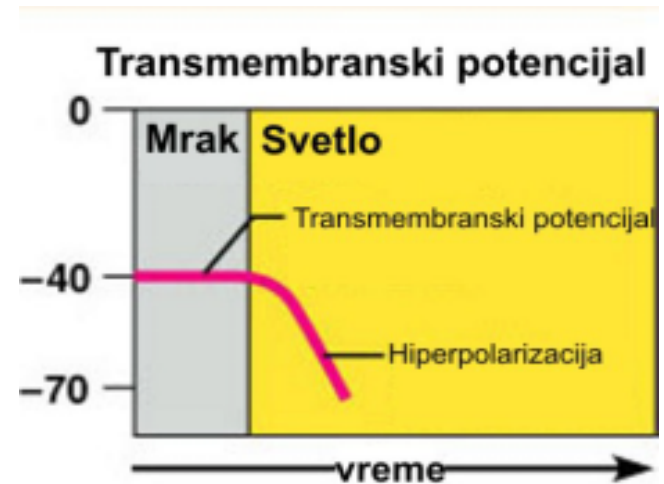
Fototransdukcija



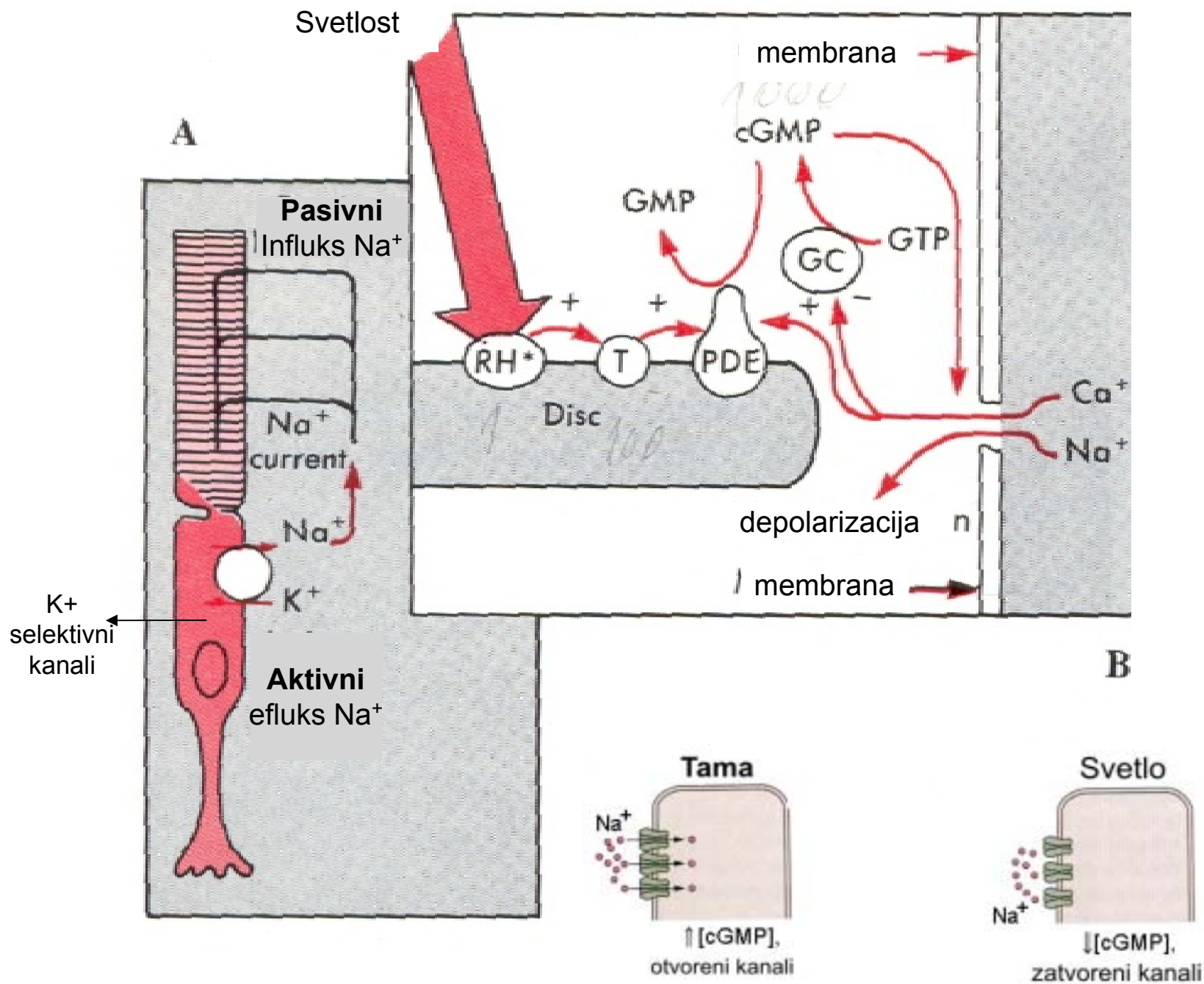
Amplifikacija

1 molekul rodopsina - 10^5 cGMP/s

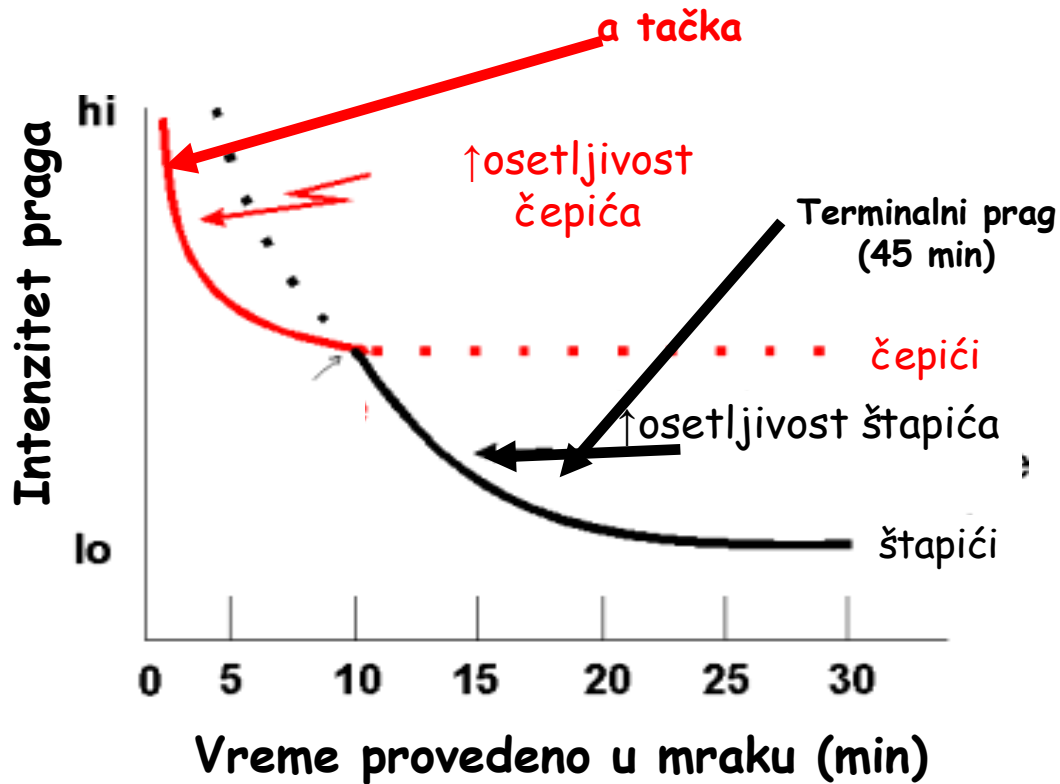
(1 rodopsin - 100tinak molekula transducina - PDE;
1 PDE - 10^3 cGMP/s)



Fototransdukcija



Adaptacija na tamu



- Tokom adaptacije na mrak, rodopsin se regeneriše i povećava se osetljivost na svetlost.
- Tokom perioda smanjene osvetljenosti, čepići se prvi adaptiraju (5-10 min), adaptacija štapića dostiže maksimum posle 30-45 min i nastavlja se tokom nekoliko sati (do 4h).
- Potpuno adaptirani štapići su osetljivi na 1 foton.
- Pri maloj osvetljenosti nije moguća percepcija boja. Oštrina vida je smanjena (fovea je najosetljivija na ivicama)

Adaptaciona sposobnost retine

Adaptacija na svetlost

pre

posle

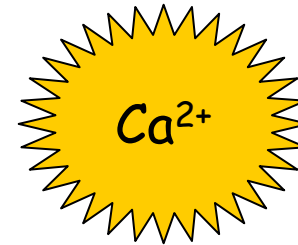


- Mioza, desenzitizacija čepića, prostorna i vremenska sumacija
- Svetlost - Stimulacija čepića i štapića, razgradnja fotopigmenta - zaslepljenost
- Smanjena osetljivost retine
- Adaptacija - smanjena aktivnost štapića, desenzitizacija čepića

Adaptaciona sposobnost retine

Mehanizmi adaptacije

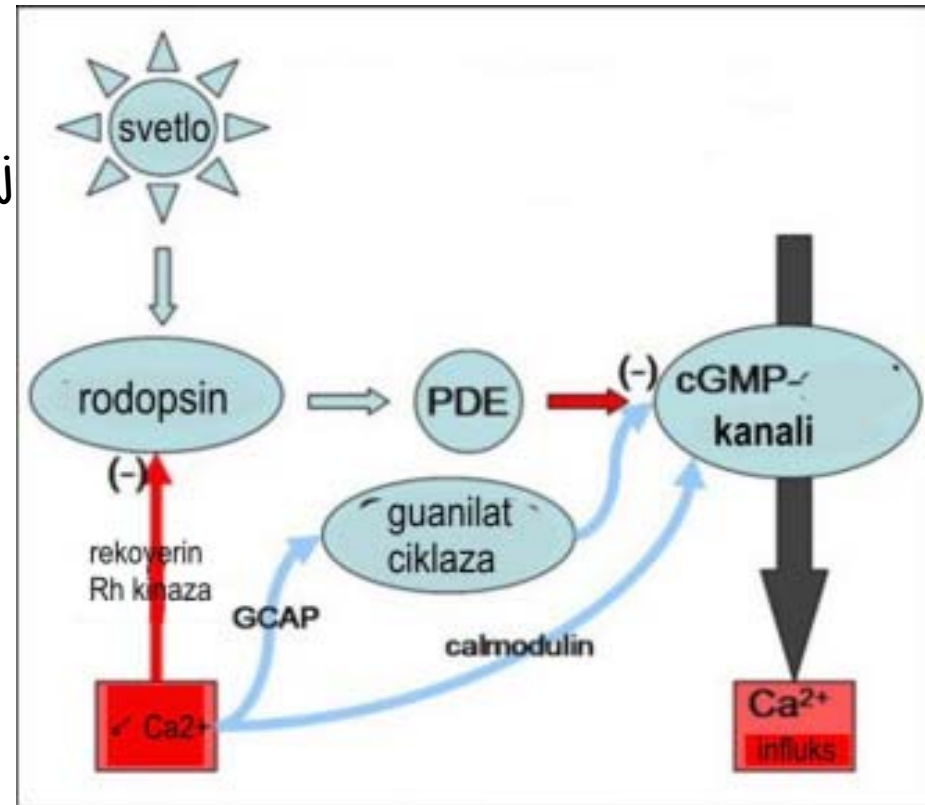
1. Reakcija zenice (mioza)



1. Fotohemijske reakcije u retini (svetlost: $\downarrow Ca^{2+}$ - GC - $\uparrow$ cGMP; defosforilacija fosducina - $\downarrow$ regeneracije transducina; rekoverin - fosforilacija metarodopsinaII)

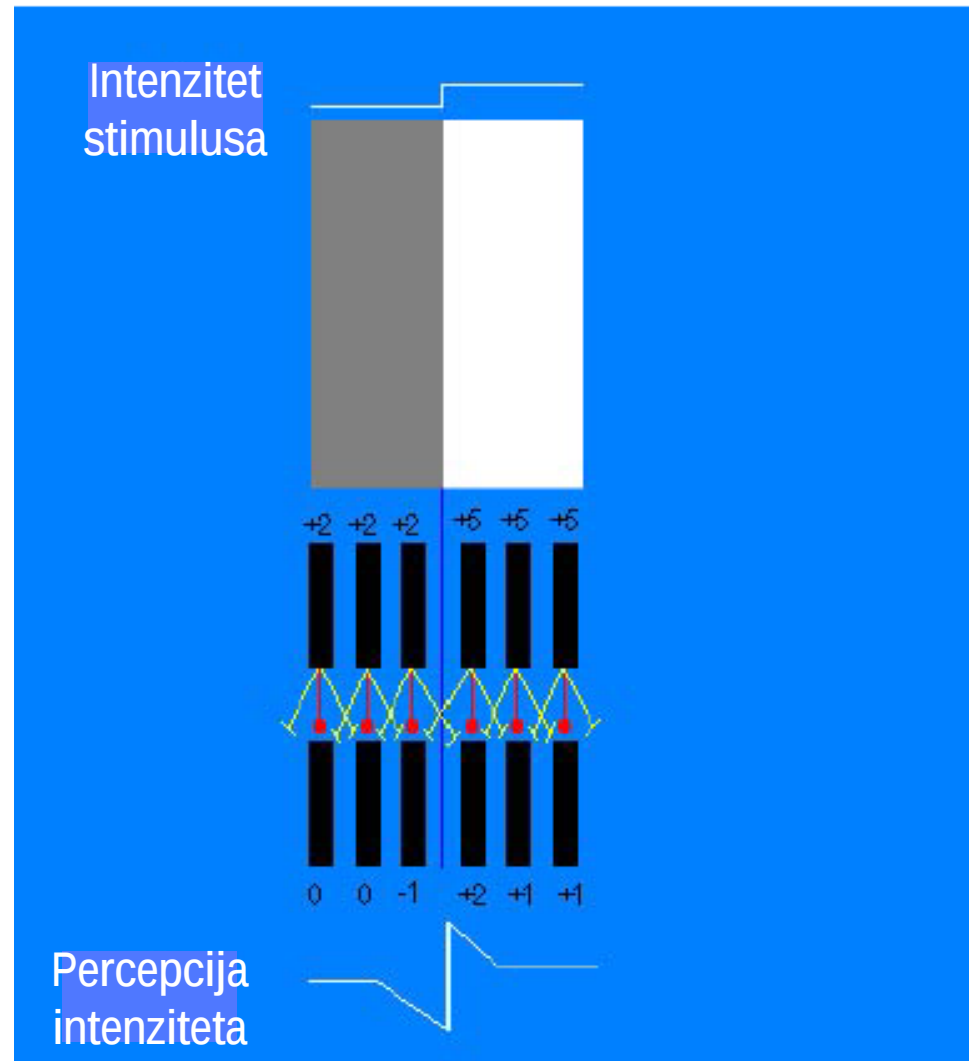
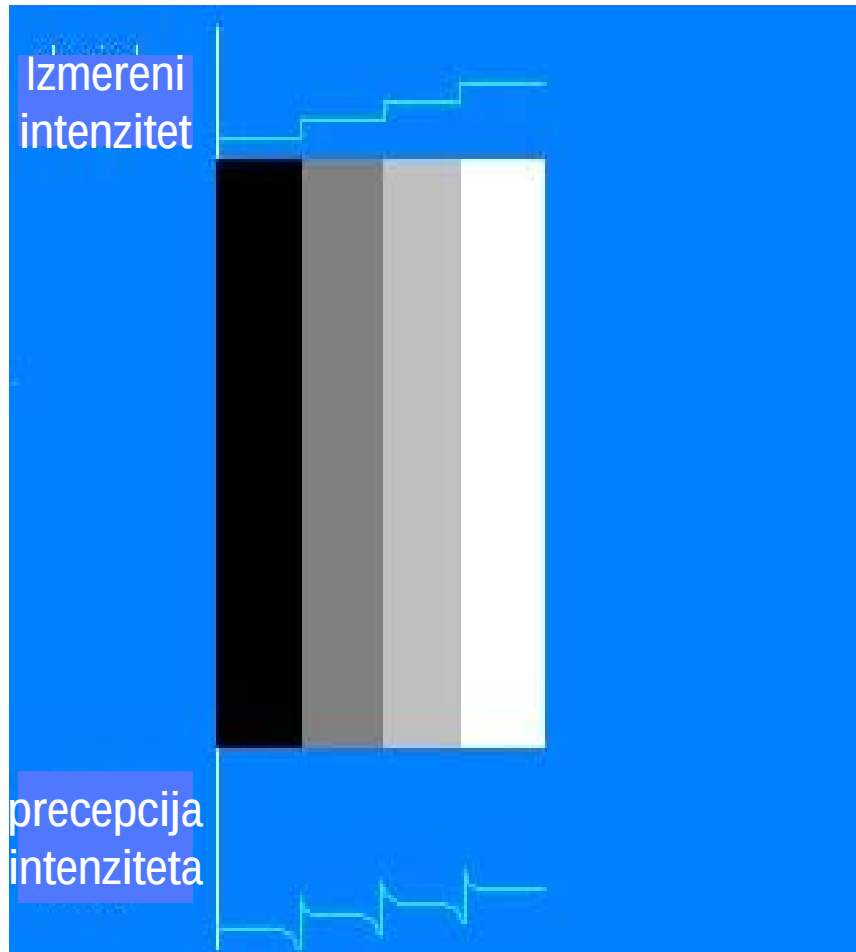
2. Prostorna sumacija ($\uparrow$ osjetljivost ganglijskih ćelija. Osvetljenje periferije ih ne inhibira)

3. Vremenska sumacija

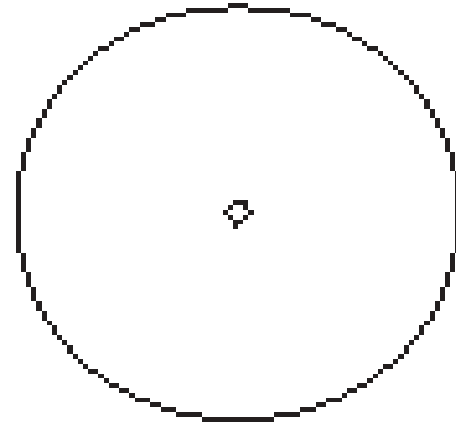


Istovremeni kontrast

Lateralna inhibicija

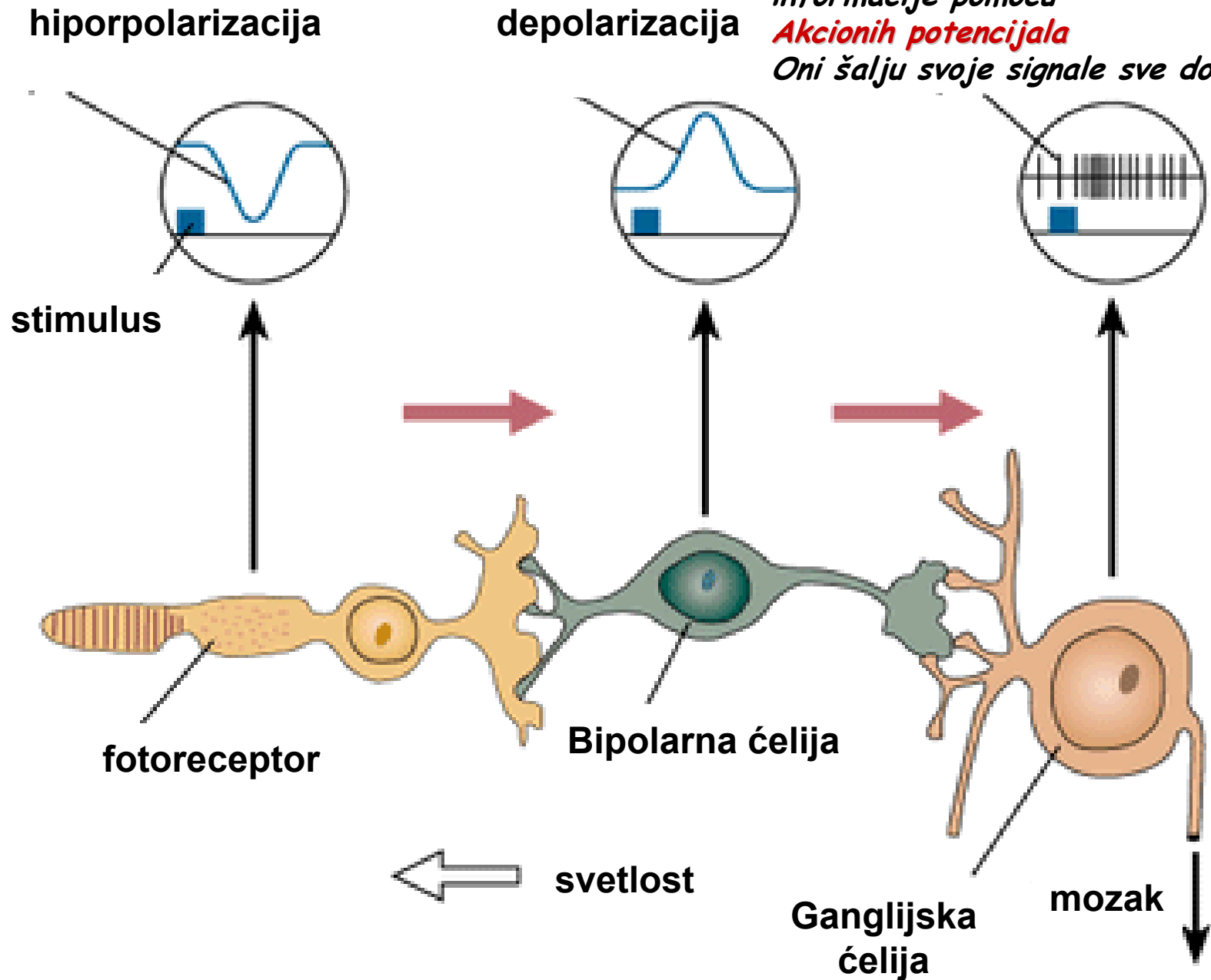


Naknadni kontrast



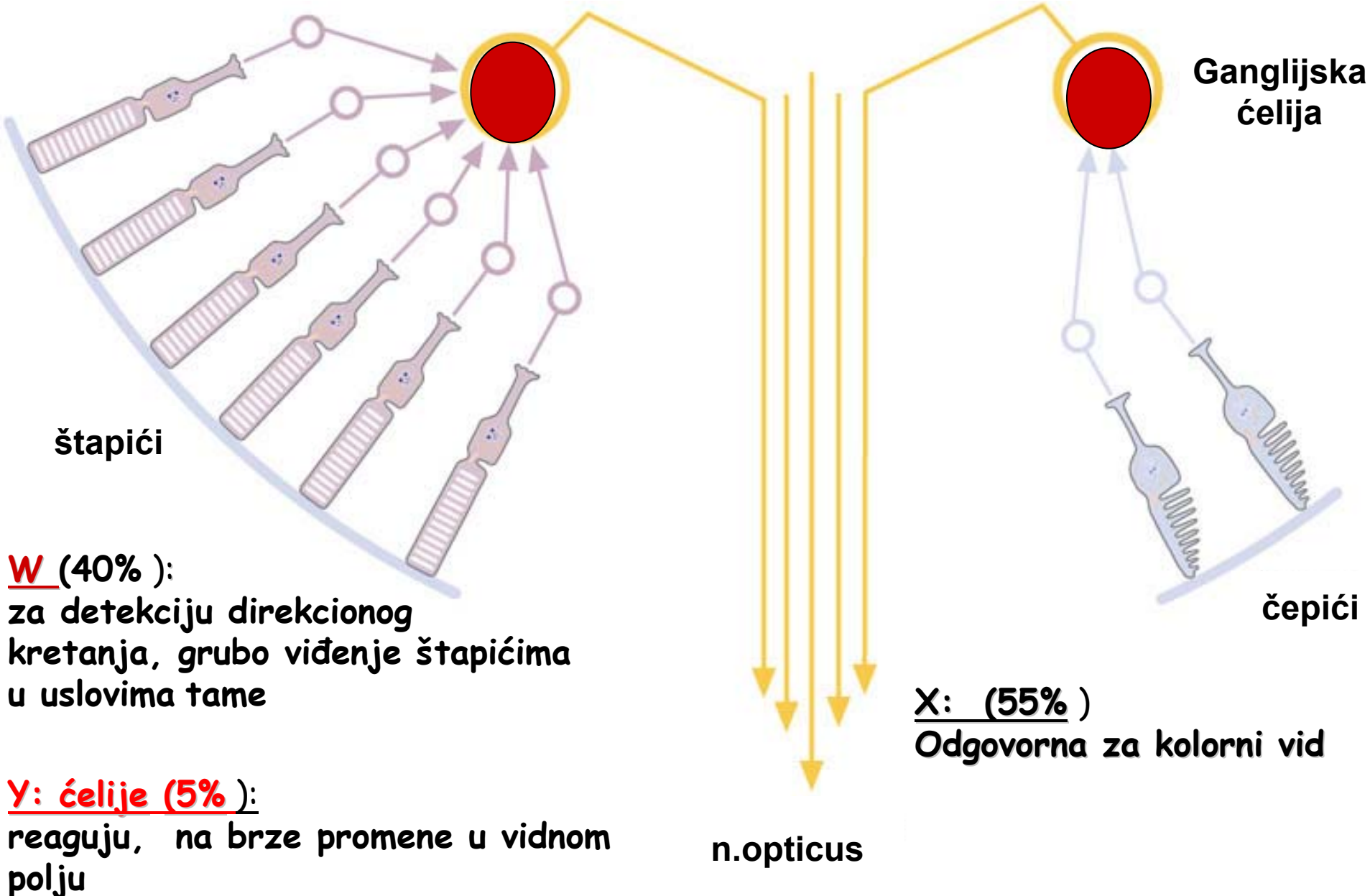
- Tokom 20s gledati crno-beli krug sa leve strane, a zatim pogledati krug sa desne strane
- Polja koja su bila crna izgledaju svetlija od okoline
- **Lokalna adaptacija retine**

Ganglijske ćelije su jedini neuroni mrežnjače koji prenose vidne informacije pomoću **Akcioni**h potencijala. Oni šalju svoje signale sve do mozga.

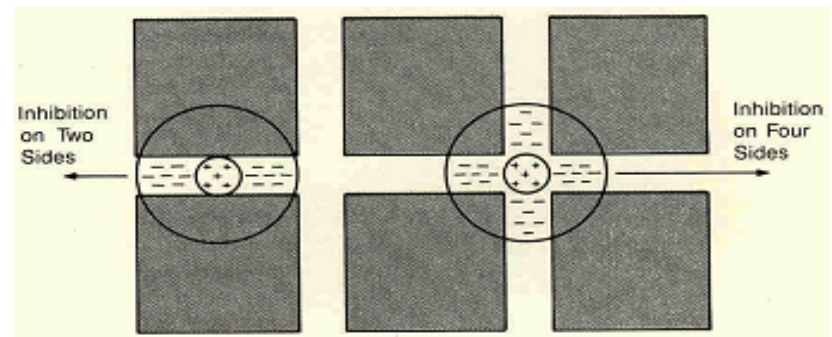
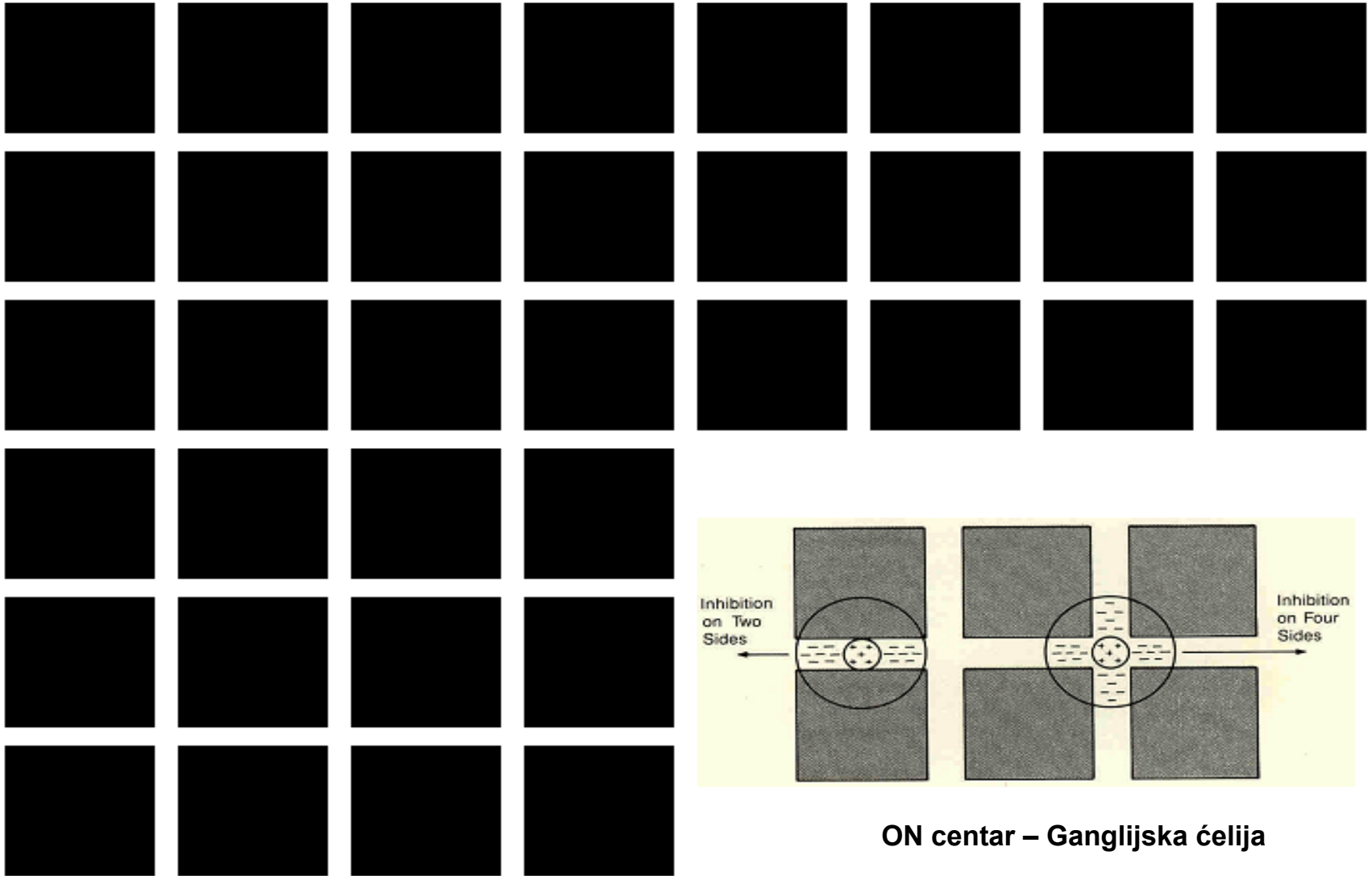


signali iz štapića (do 200) se sumiraju (konvergiraju) dajući intenzivniju stimulaciju perifernih ganglijskih ćelija.

GANGLIJSKE ĆELIJE



Ganglijske ćelije.



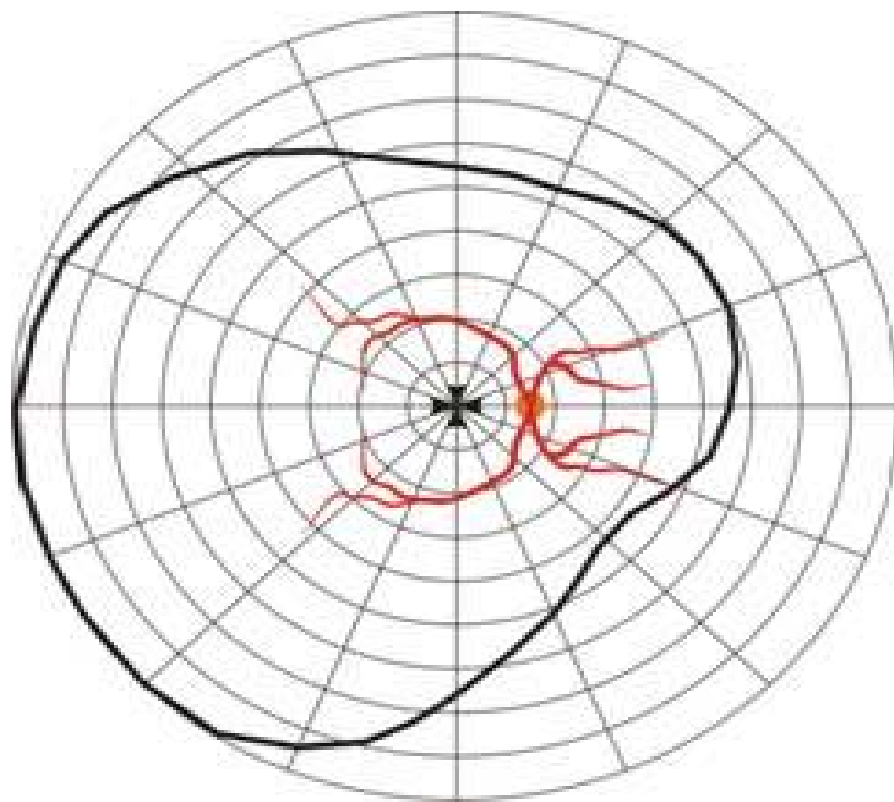
ON centar – Ganglijska ćelija

VIDNO POLJE

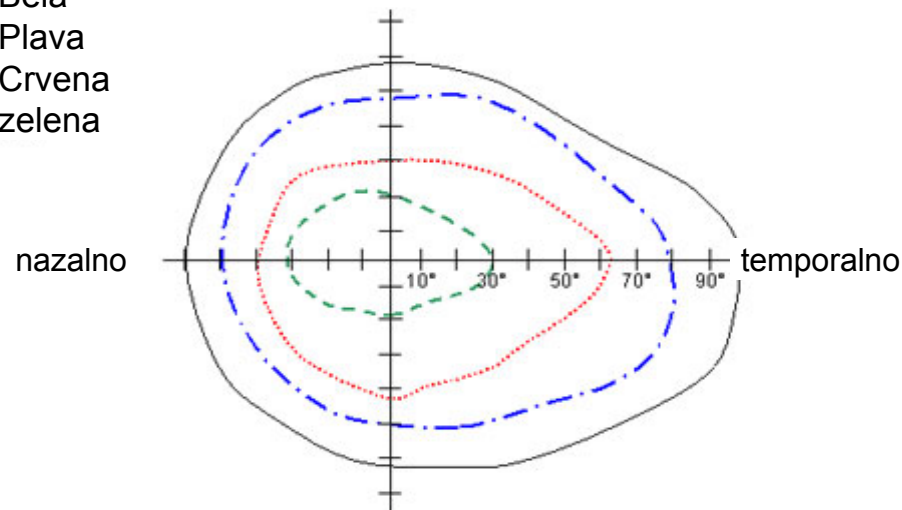
deo prostora koji se vidi

- jednim okom
- Fiksiranog pogleda napred i fiksirane glave

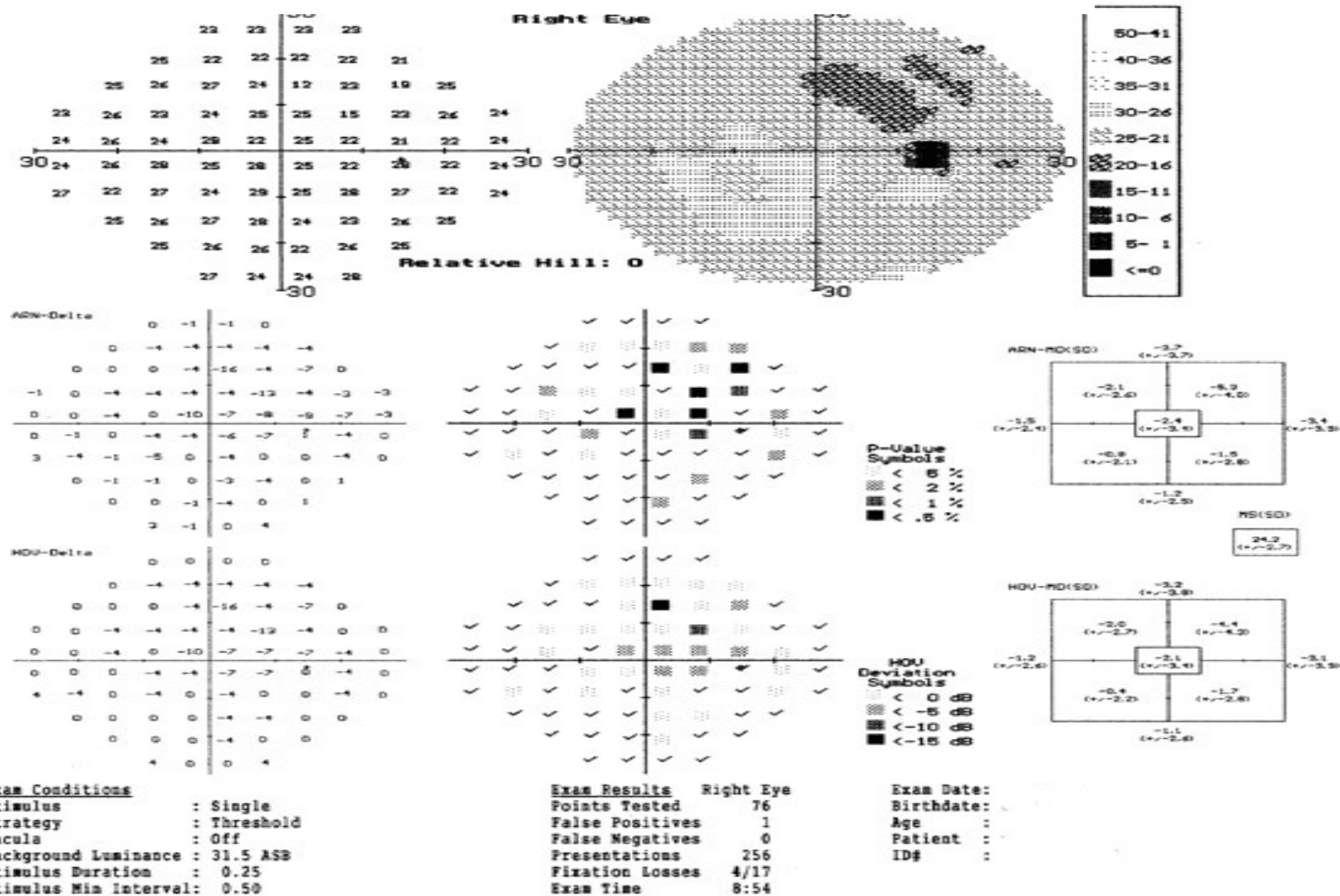
Ispituje se funkcija retine i vidnog puta



- Bela
- - - Plava
- Crvena
- - - zelena

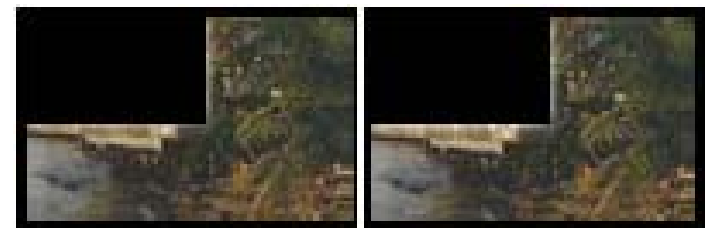
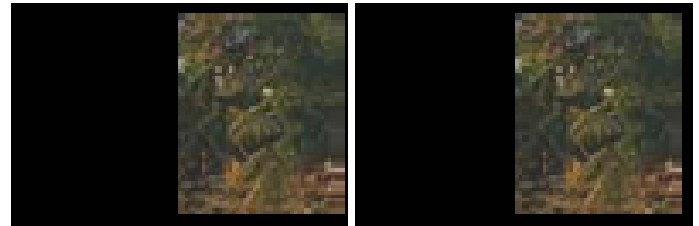
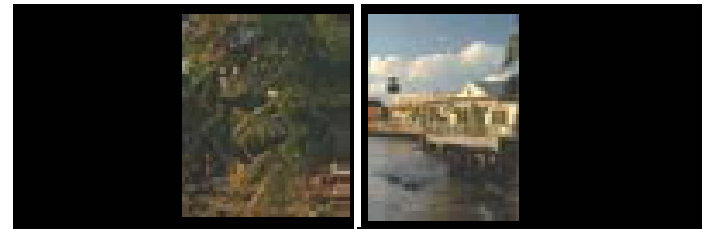
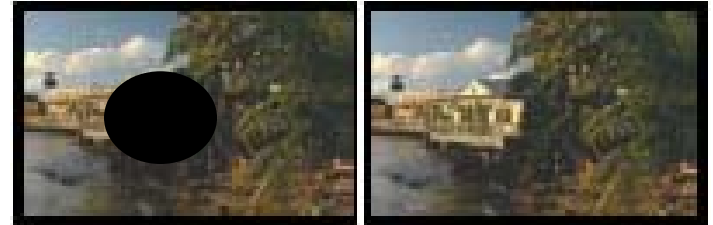


Perimetrija

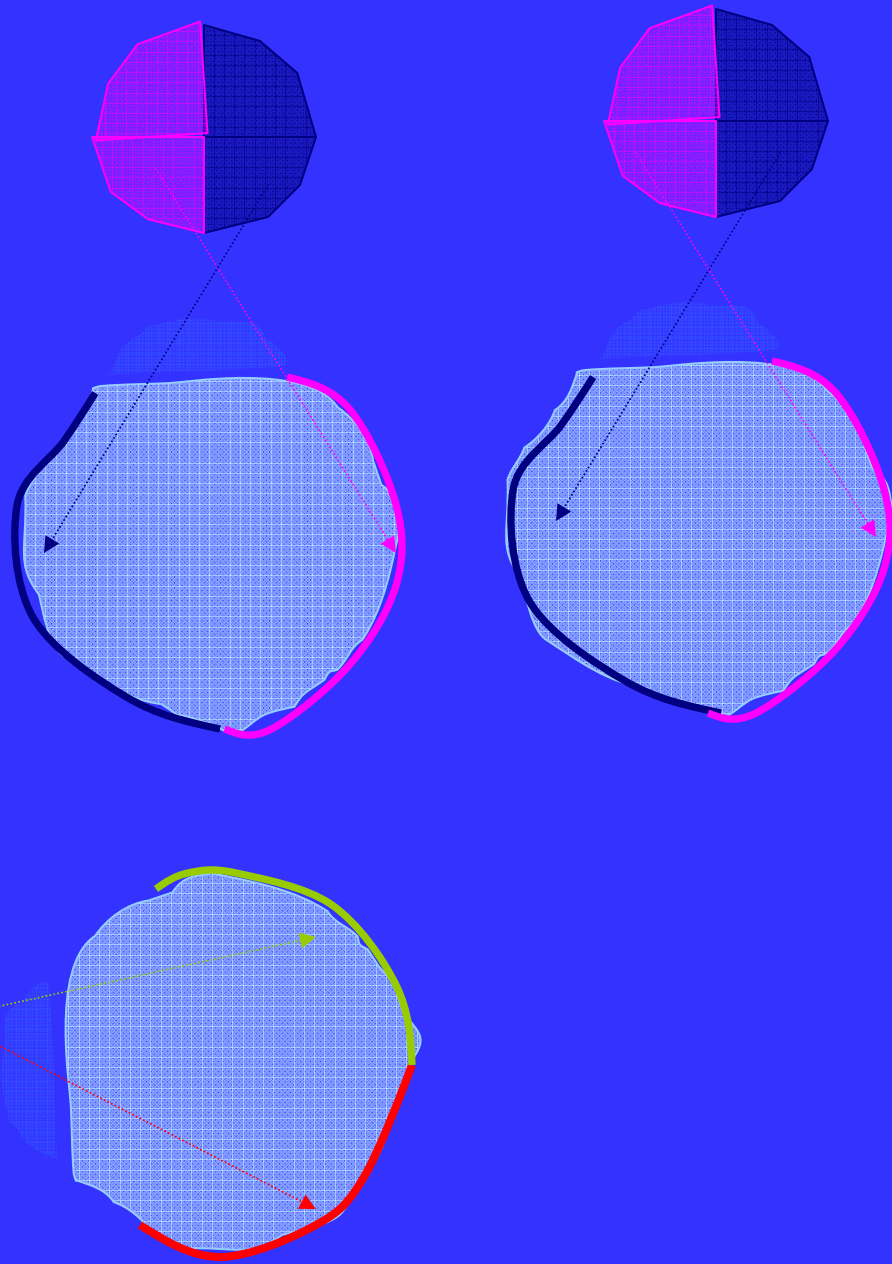


Ispadi u vidnom polju

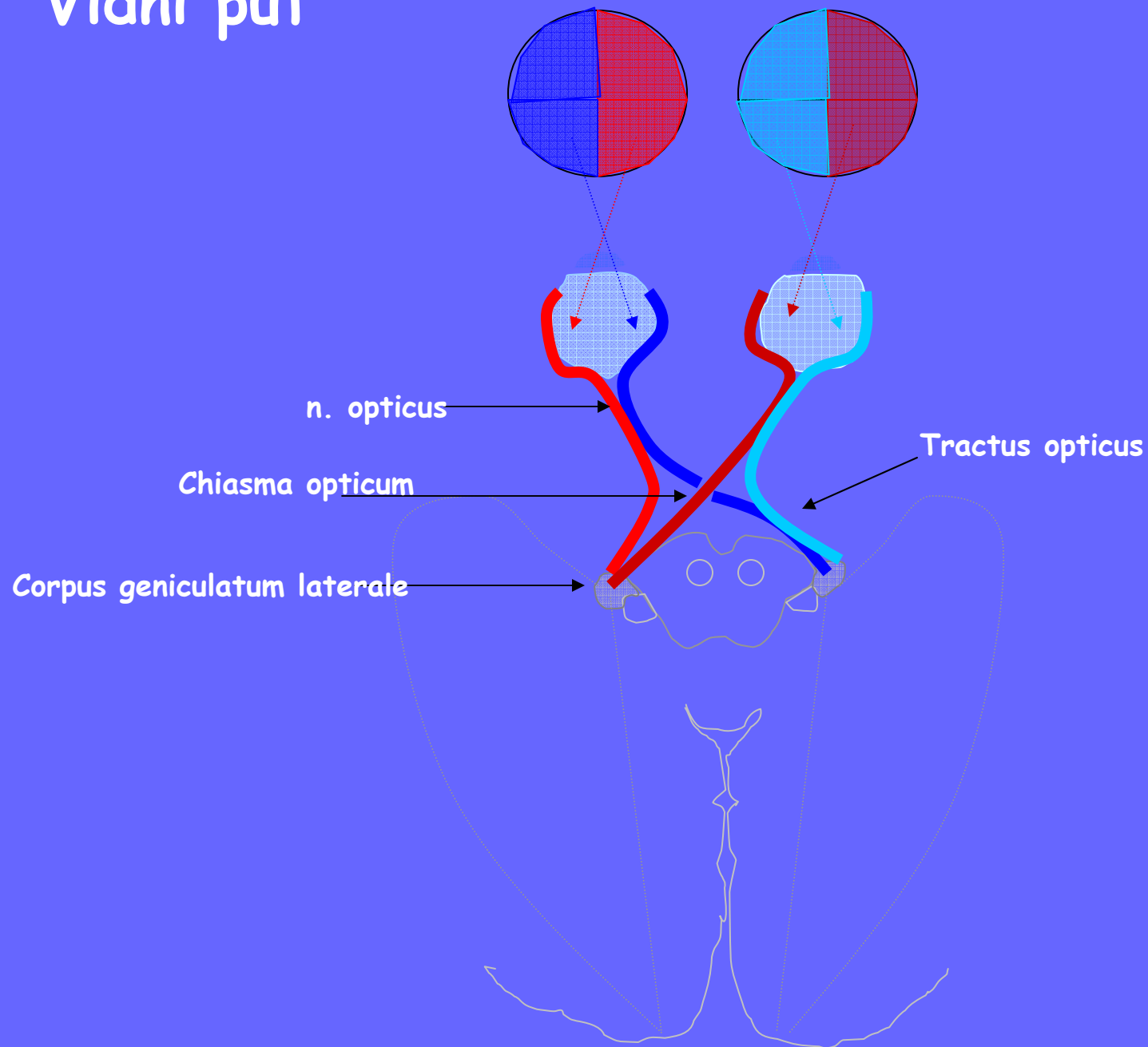
- Skotomi (tačkasti ispadi)
- Hemianopsije (homonimna heteronimna)
- Kvadratne anopsije



Inverzija



Vidni put



Corpus geniculatum laterale

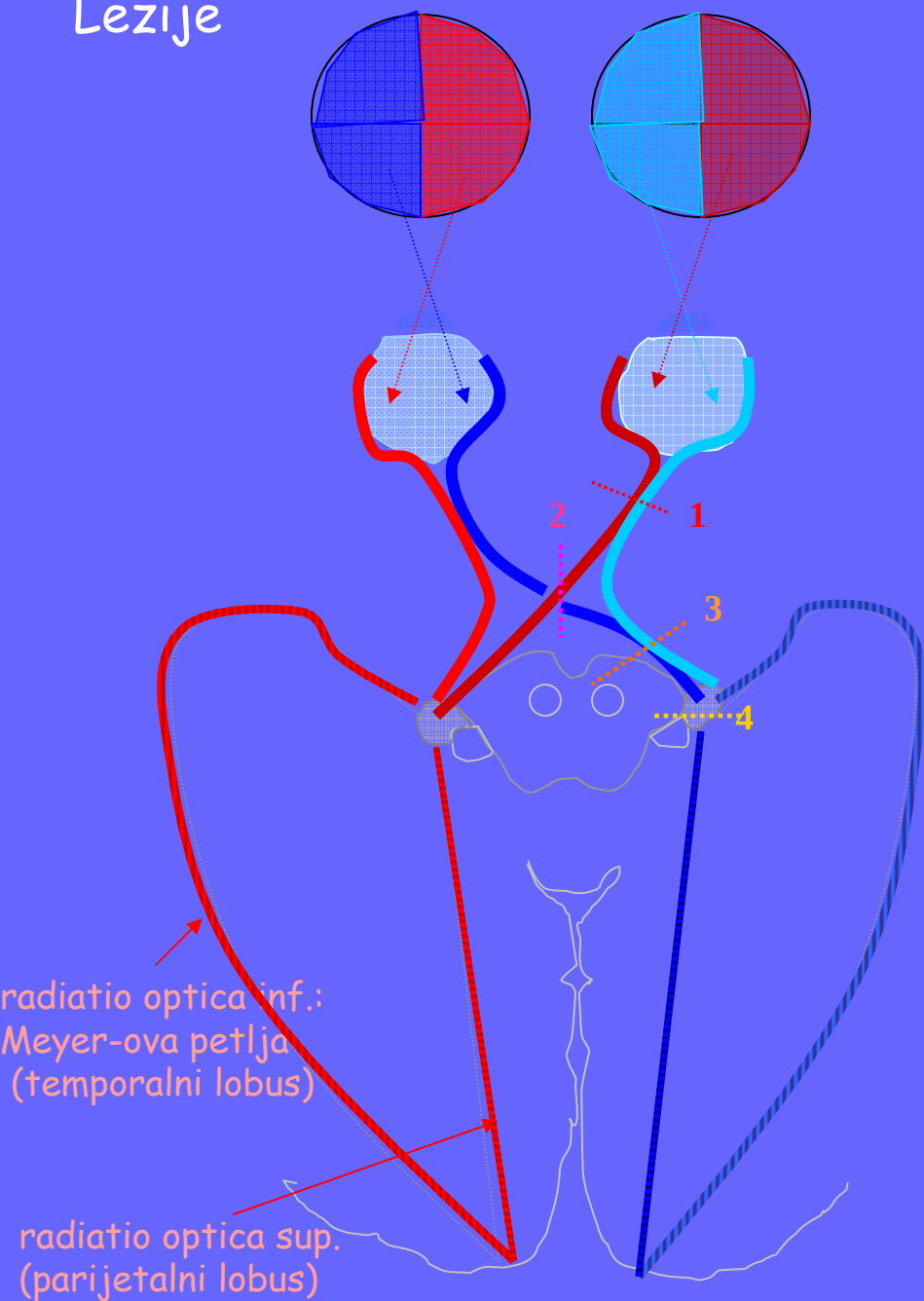


CGL

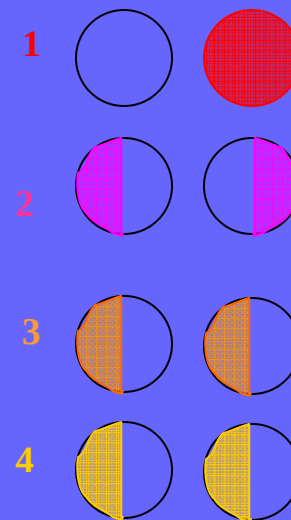
PARVOCELULARNI
(spoljashnja 4 sloja)
Boja, precizan vid,
fovea

MAGNOCELULARNI
unutrasnja 2 sloja,
Mala preciznost,
pokret, periferija

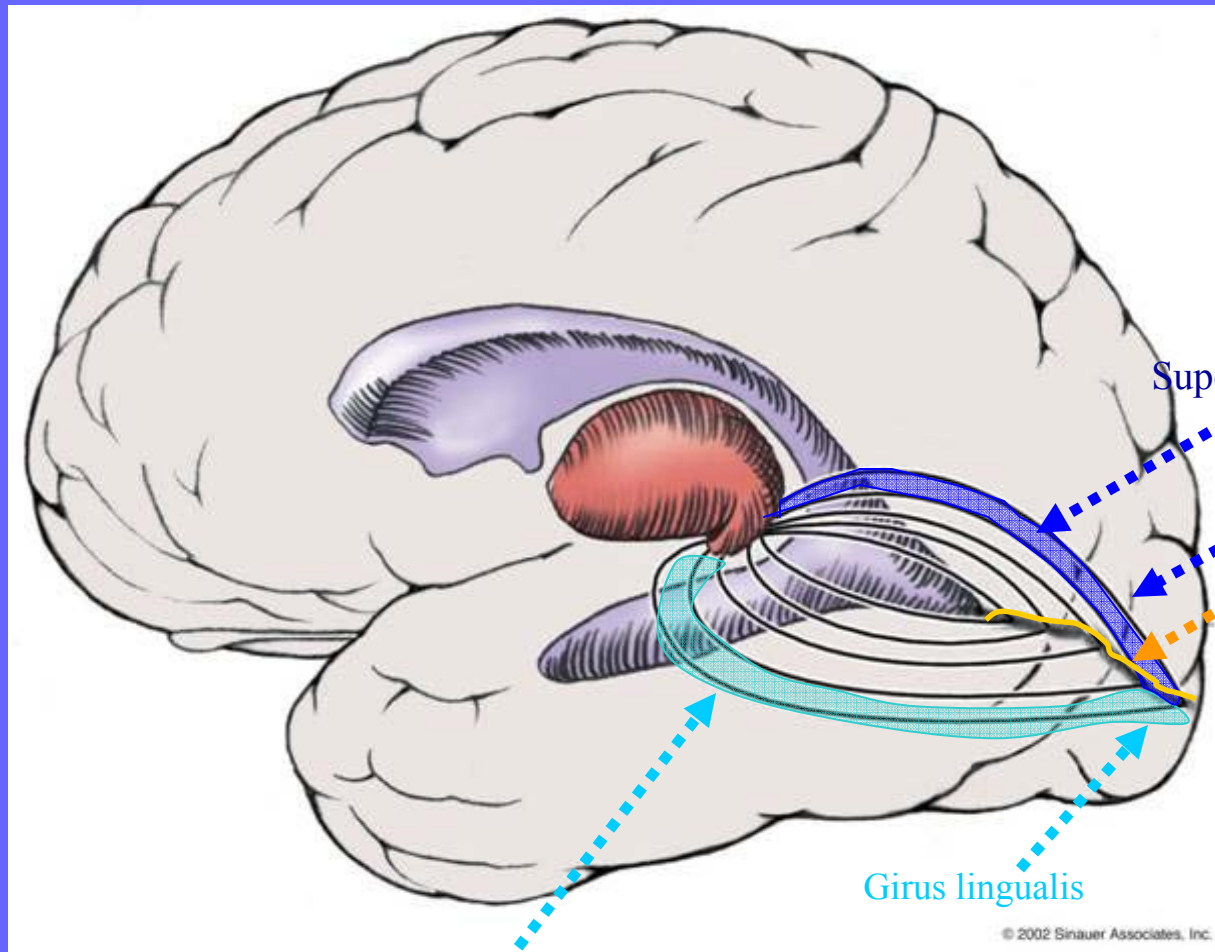
Lezije



Ispad u vidnom polju



Radiatio optica



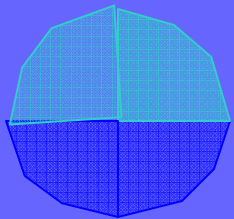
Superior radiatio optica

Cunneus

Sulcus Calcarinus

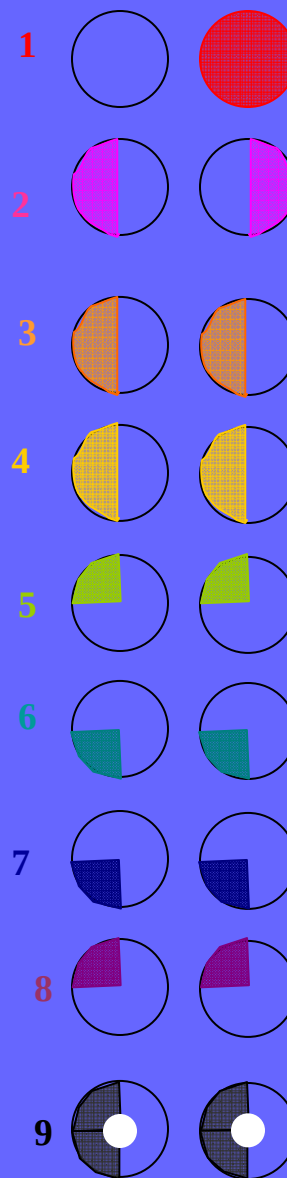
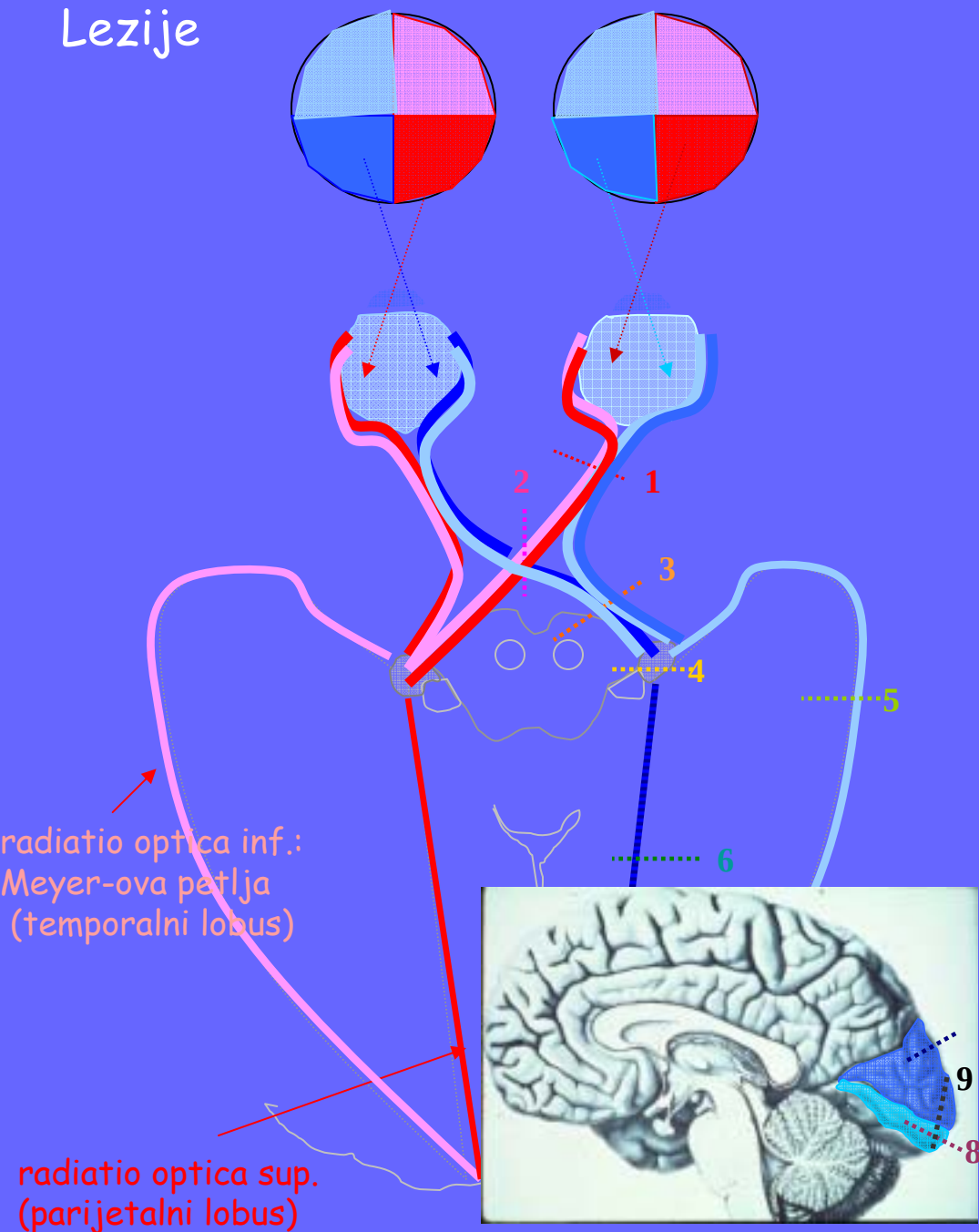
Girus lingualis

Meyer-ova petlja
Inferior radiatio optica



Lezije

Ispad u vidnom polju



Adaptaciona sposobnost retine

Adaptacija na tamu

pre adaptacije



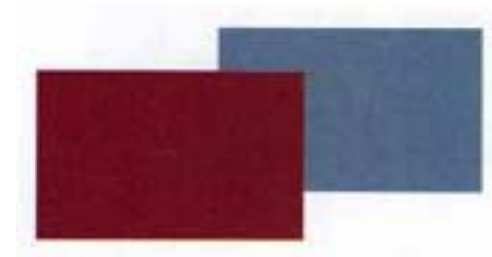
posle adaptacije



1. Dilatacija pupile
2. Fotohemijske reakcije u retini
3. Prostorna i vremenska sumacija

3D percepcija (dubine) - monokularni vid

- Interpozicija
(preklapanje objekata)



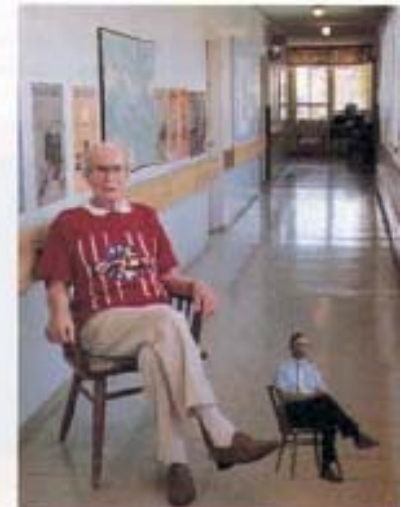
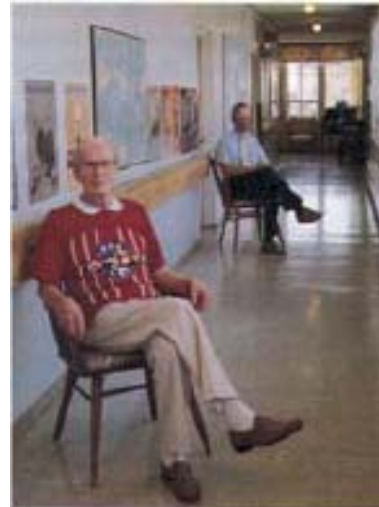
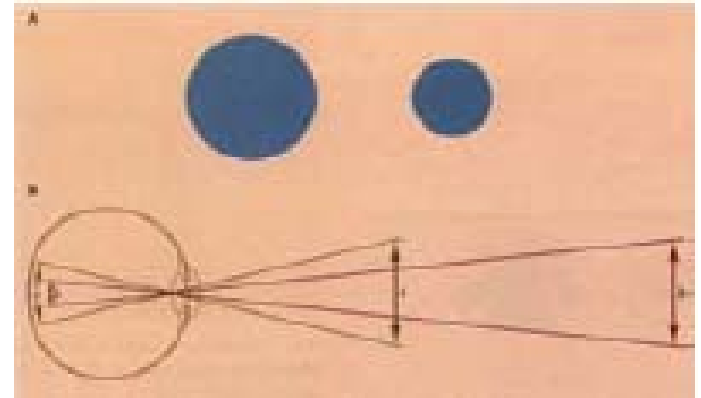
3D percepcija (dubine) – monokularni vid

- Interpozicija
(preklapanje objekata)
- **Linearna perspektiva**



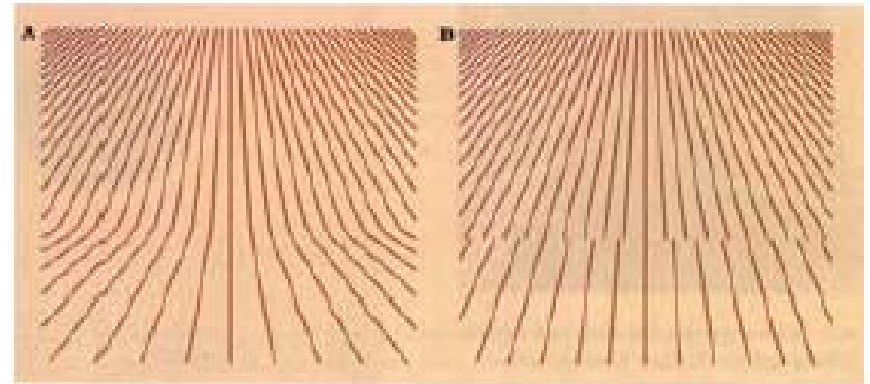
3D percepcija (dubine) - monokularni vid

- Interpozicija (preklapanje objekata)
- Linearna perspektiva
- **Relativna veličina predmeta**



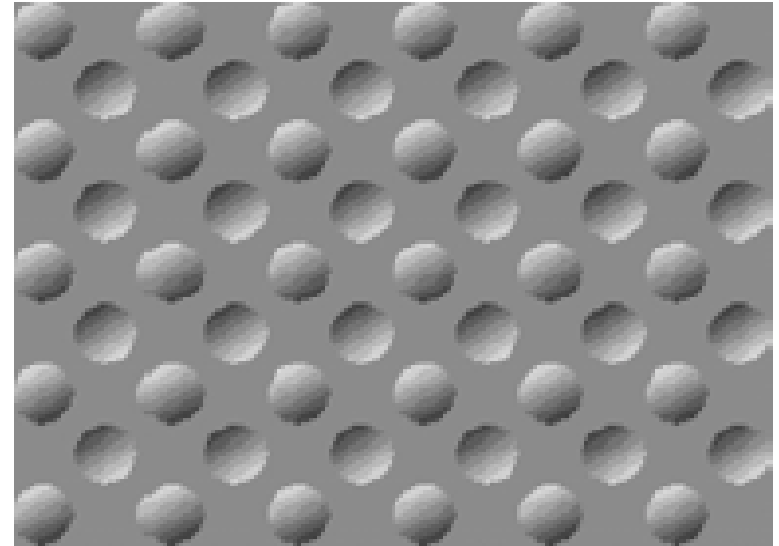
3D percepcija (dubine) - monokularni vid

- Interpozicija (preklapanje objekata)
- Linearna perspektiva
- Relativna veličina predmeta
- **Gradijent teksture**



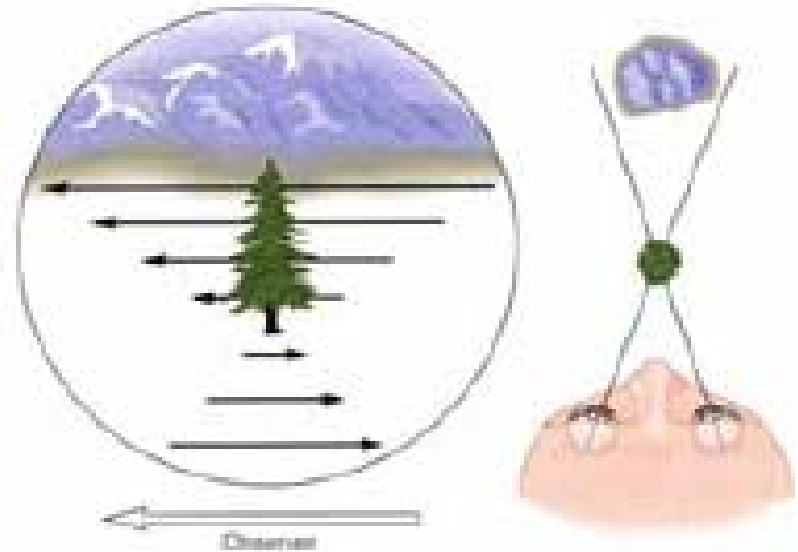
3D percepcija (dubine) - monokularni vid

- Interpozicija (preklapanje objekata)
- Linearna perspektiva
- Relativna veličina predmeta
- Gradijent teksture
- **Svetlost i senka** (svetliji predmeti su bliži)

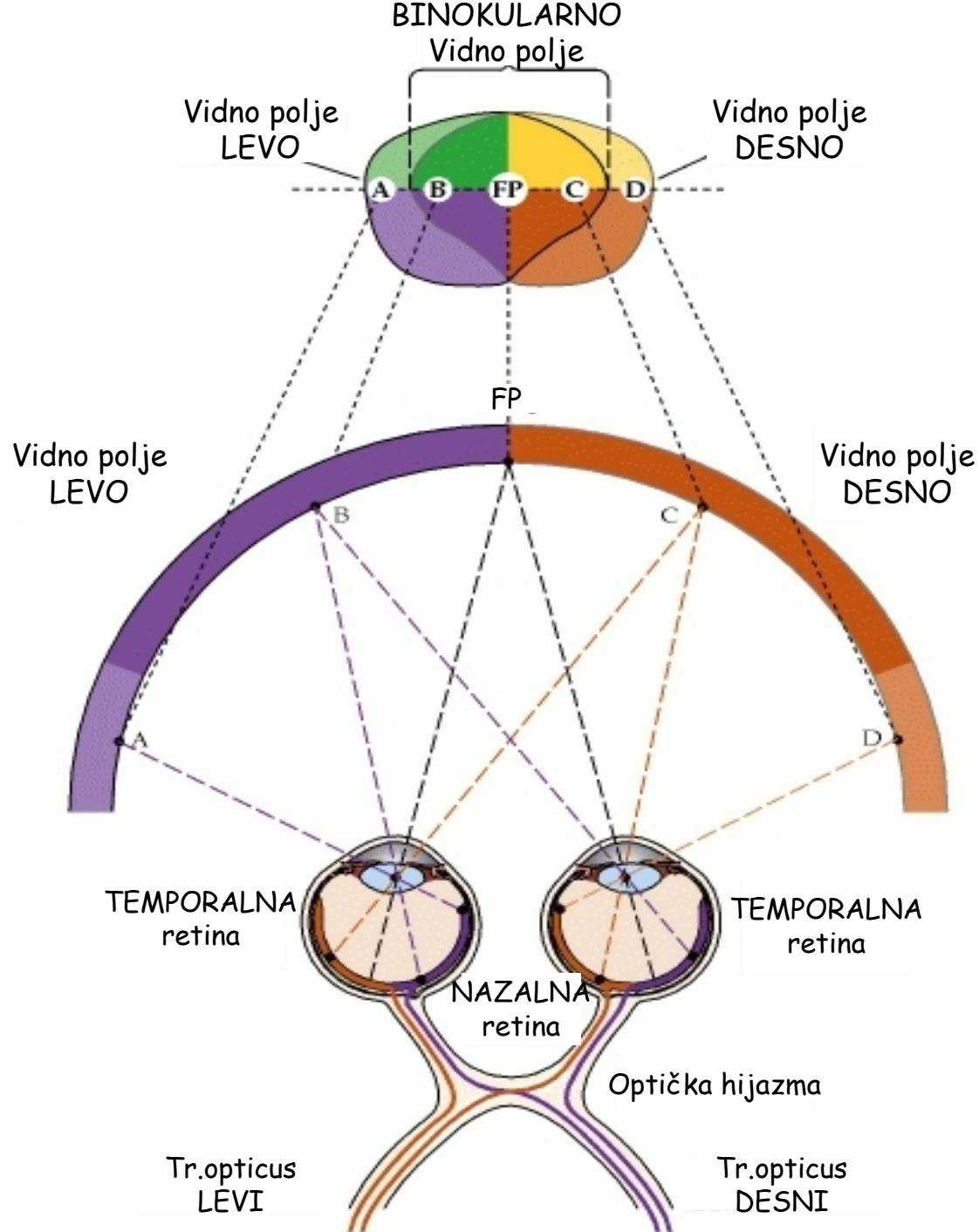


3D percepcija (dubine) - monokularni vid

- Interpozicija (preklapanje objekata)
- Linearna perspektiva
- Relativna veličina predmeta
- Gradijent tekstone
- Svetlost i senka (svetliji predmeti su bliži)
- Paralaksa pri kretanju



3D
percepcija
(dubine)
binokularni
vid



Teze

- Akomodacija (definicija, mehanizam, prezbiopija)
- Refleks zenice na svetlost (direktna, konsenzualna reakcija)
- Fotosenzitivni deo retine (distribucija fotoreceptora, slepa mrlja)
- Oštrina vida
- Adaptacija na svetlost i tamu (fotohemija vida)
- Istovremeni i naknadni kontrast
- Monokularna i binokularna percepcija dubine
- Vidni put (širina vidnog polja)