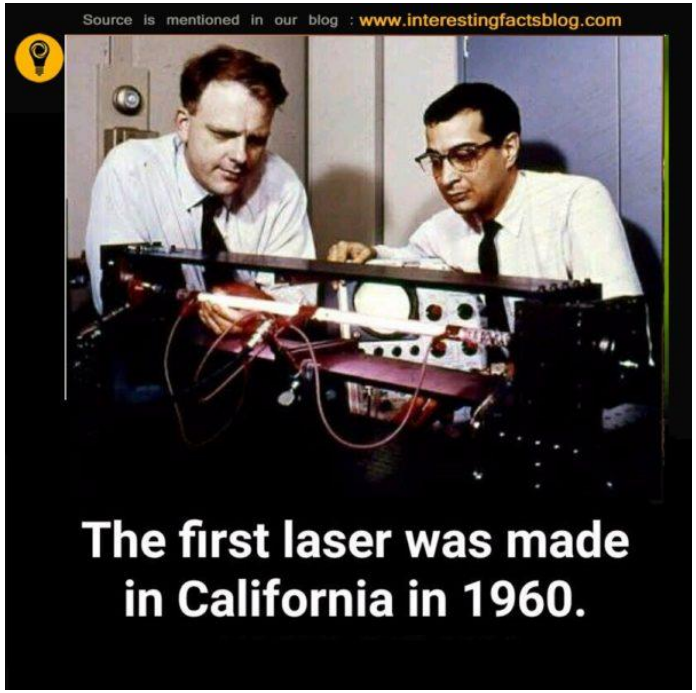
Lasers in ophthalmology

University of Szeged
Department of Ophthalmology

Definition



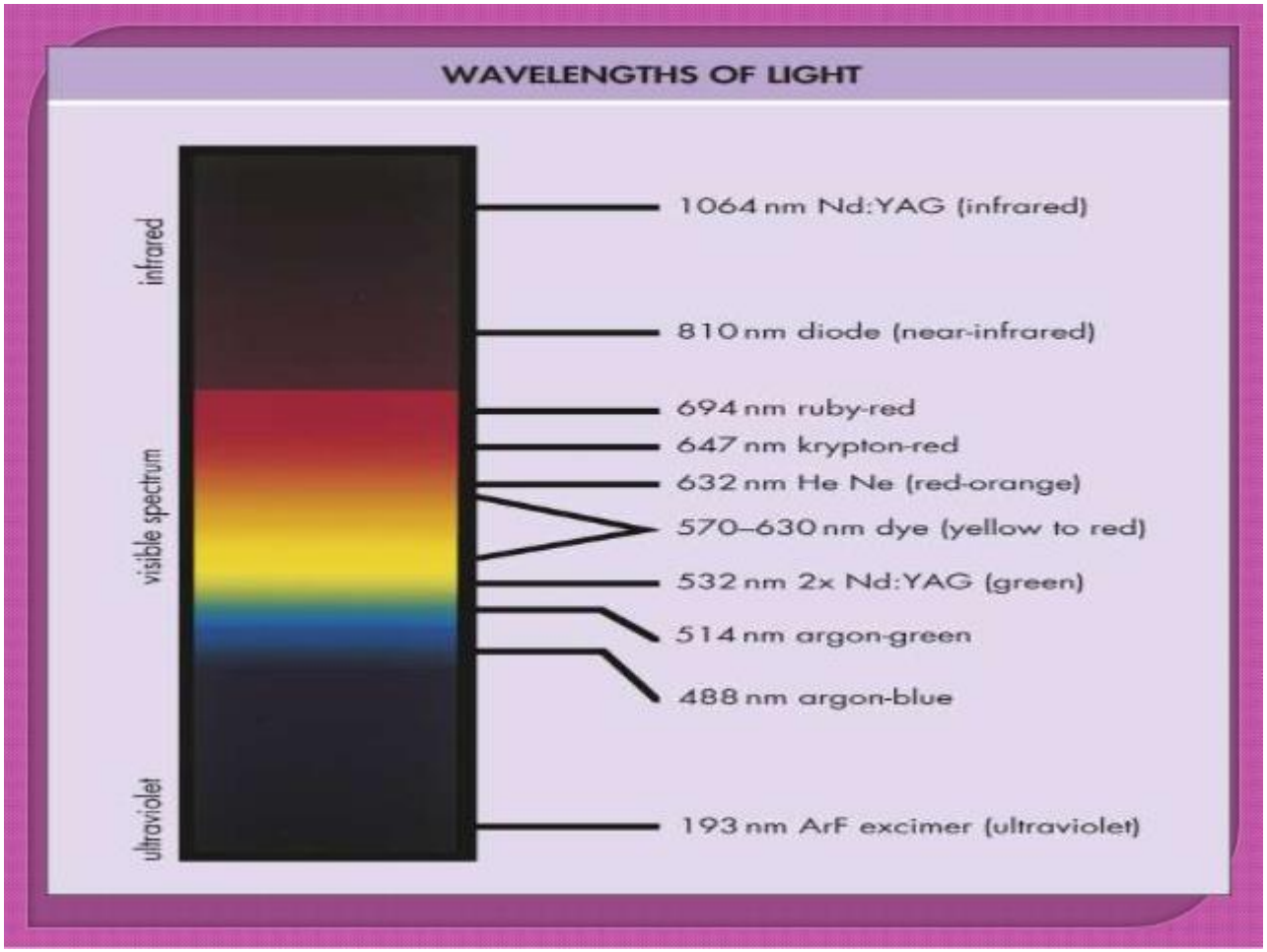
LASER is an acronym for

- **L** Light
- **A** Amplification (by)
- **S** Stimulated
- **E** Emission (of)
- **R** Radiation

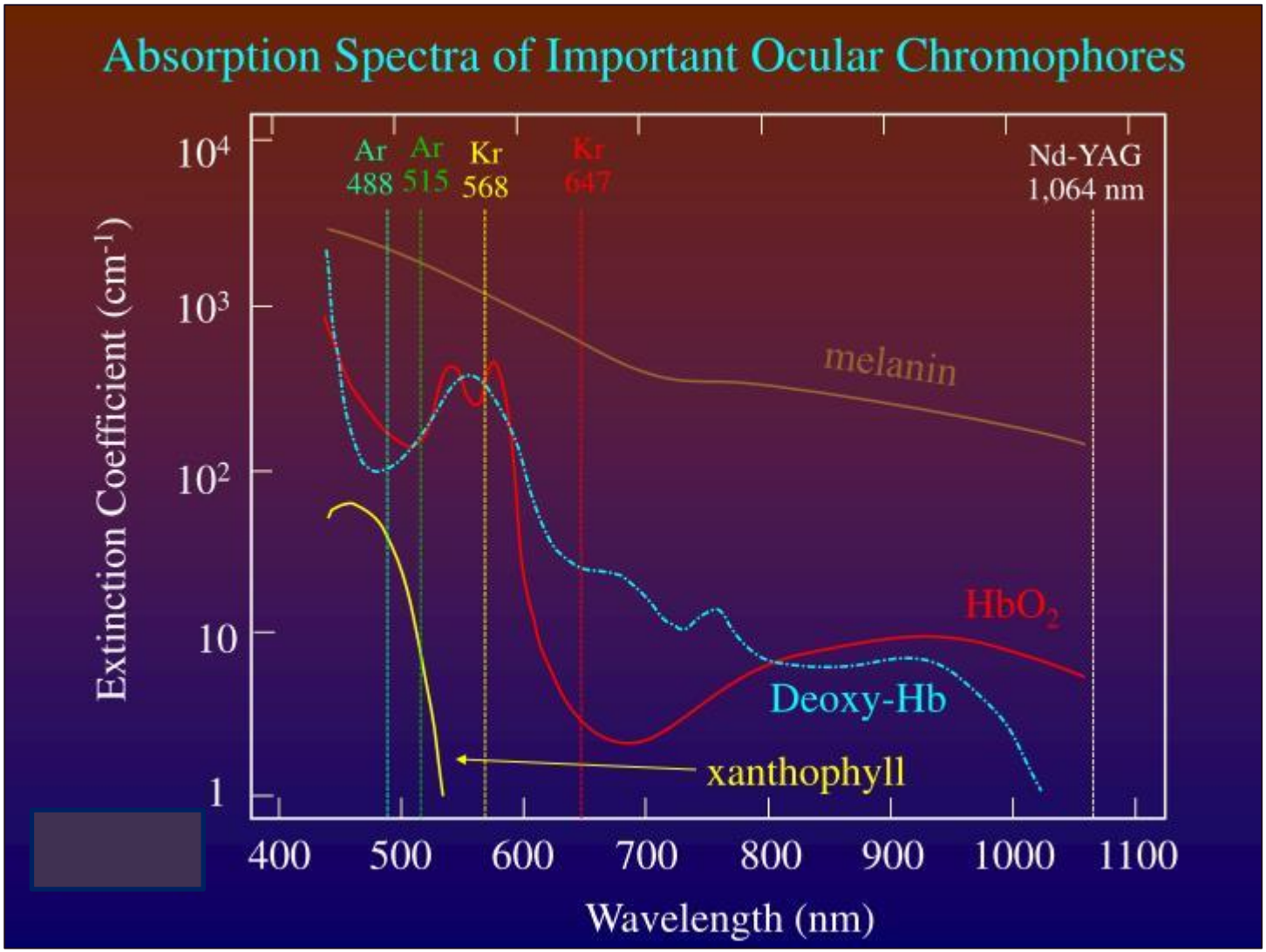
The laser is a source of coherent, directional, monochromatic light that can be precisely focused into a small spot. The laser is a very useful tool for a wide variety of clinical **diagnostic** and **therapeutic** procedures.

- Types of ophthalmic lasers
- Absorbtion spectras of important ocular chromophores
- Laser- tissue interactions
- Laser- therapeutic applications
- Laser- diagnostic applications

Types of ophthalmic lasers



Wavelength range of ophthalmic lasers extends from 193nm to 1064nm, including the visible spectrum: approximately between 400 and 750 nm


Absorption Spectra of Important Ocular Chromophores
Extinction Coefficient (cm-1)
10^4
10^3
10^2
10
1
Ar 488
Ar 515
Kr 568
Kr 647
Nd-YAG 1,064 nm
melanin
HbO2
Deoxy-Hb
xanthophyll
400
500
600
700
800
900
1000
1100
Wavelength (nm)

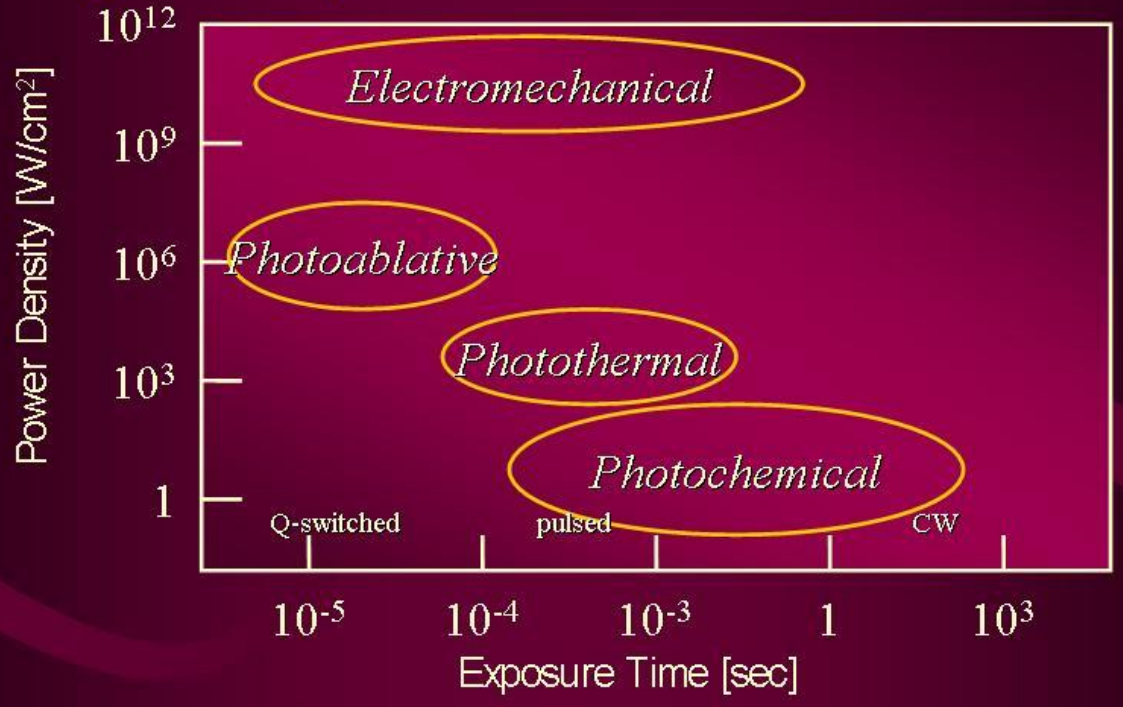
Laser-Tissue Interactions

Interactions of light with biological tissues depend on it's

- wavelength
- pulse duration
- irradiance (amount of power per unit area, W/cm2)

Bioeffects of Lasers

Laser/tissue interaction depends on power density and exposure time



LIGHT- TISSUE INTERACTIONS
thermal effect

Photocoagulation:

Laser Light
↓
Target Tissue
↓
Generate Heat
↓
Denatures Proteins
(Coagulation)

Rise in temperature of about 10 to 20 ^{0}C (to 50-60 ^{0}C) will cause coagulation of tissue.

LIGHT -TISSUE INTERACTIONS
thermal effect

Photodisruption:

Laser Light

↓

Acustic shock waves (thunderclap)

↓

Tissue ruptures as a result of the vapor bubbles

↓

Tissue Damage

(between 100 and 305 °C)

LIGHT -TISSUE INTERACTIONS thermal effect

Vaporization

- With wery high pover of densitises, lasers will quickly heat the tissues with temperatue between 60—100 ^0C or above. Water within the tissues boils and evaporates.
- Photo- vaporization results in complete removal of the tissue

https://www.researchgate.net/figure/Laser-tissue-interaction_fig15_258140573

LIGHT -TISSUE INTERACTIONS photochemical effect

Photoablation:

Breaks the chemical bonds that hold tissue together, essentially vaporizing the tissue.

- Photorefractive Keratectomy,
- Argon Fluoride (ArF)
- Excimer Laser.

LIGHT -TISSUE INTERACTIONS photochemical effect

PHOTORADIATION (PDT):

Also called Photodynamic Therapy

Photochemical reaction following visible/infrared light particularly after administration of exogenous chromophore.

Commonly used photosensitizers:

- Hematoporphyrin
- Benzaporphyrin Derivatives

Treatment of ocular tumour and choroidal neovascularisatin (CNV)

LIGHT -TISSUE INTERACTIONS

Ionization effect

- Highly energized focal laser beam is delivered on tissue over a period of nanosecond or picoseconds and produce plasma in target tissue.
- Q Switching Nd.Yag

  ↓

  Ionization (Plasma formation)

  ↓

  Absorption of photon by plasma

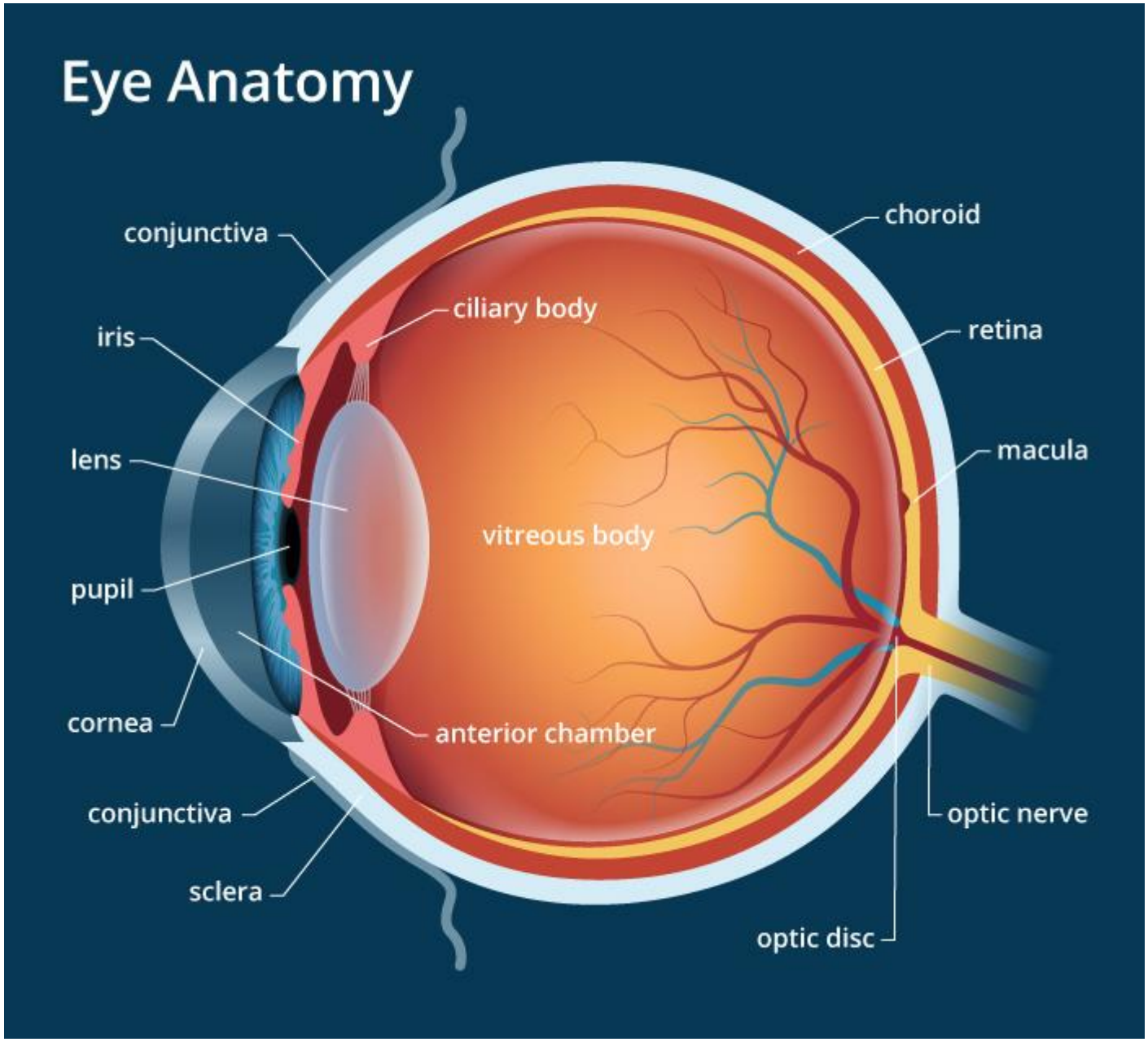
  ↓

  Increase in temperature and expansion of supersonic velocity

  ↓

  Shock wave production → Tissue Disruption

Therapeutic application of lasers


Eye Anatomy
conjunctiva
iris
lens
pupil
cornea
conjunctiva
sclera
ciliary body
vitreous body
anterior chamber
choroid
retina
macula
optic nerve
optic disc

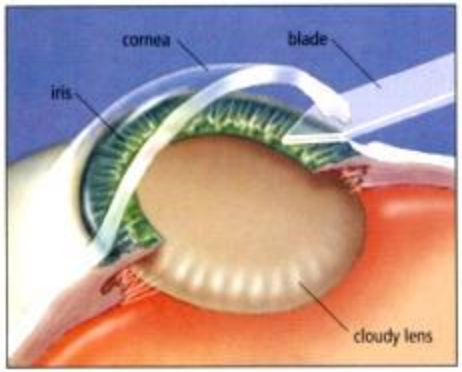
ND:YAG laser

- Neodymium-doped-yttrium- aluminium garnet is a crystal that is used as a lasing medium for solid-state lasers
- ND: YAG lasers tipically emmit light with a wavelength of 1064nm in the infrared

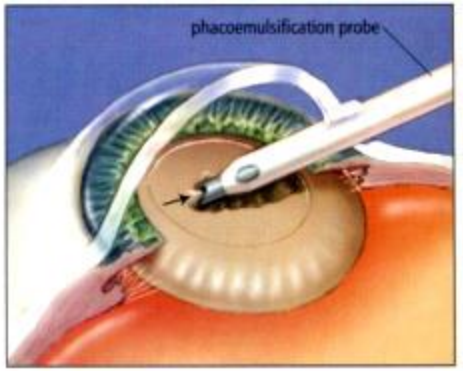
Application:

- correct posterior capsular opacification
- peripheral iridotomy in patients with angle- closure glaucoma
- laser trabeculoplasty in open angle glaucma
- freqency doubled ND:YAG lasers (wavelength 532nm) are used for pan-retinal photocoagulation in patients with diabetic retinopathy

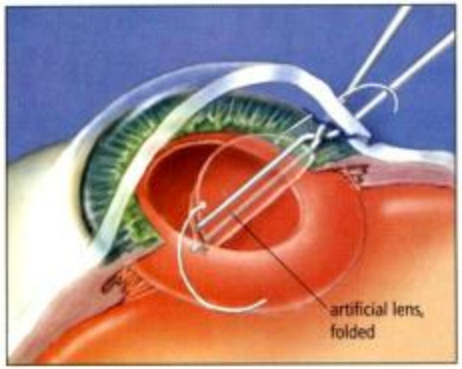
Opacifcation of the lens (Cataract)



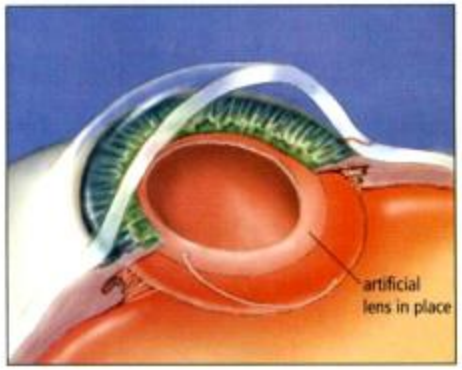
1. Incision: A small incision, approximately 3mm in width, is made at the corneal margin.



2. Emulsification: Phacoemulsification probe is inserted through corneal incision and ultrasound breaks cataract up into microscopic fragments, which can then be aspirated using the probe tip.



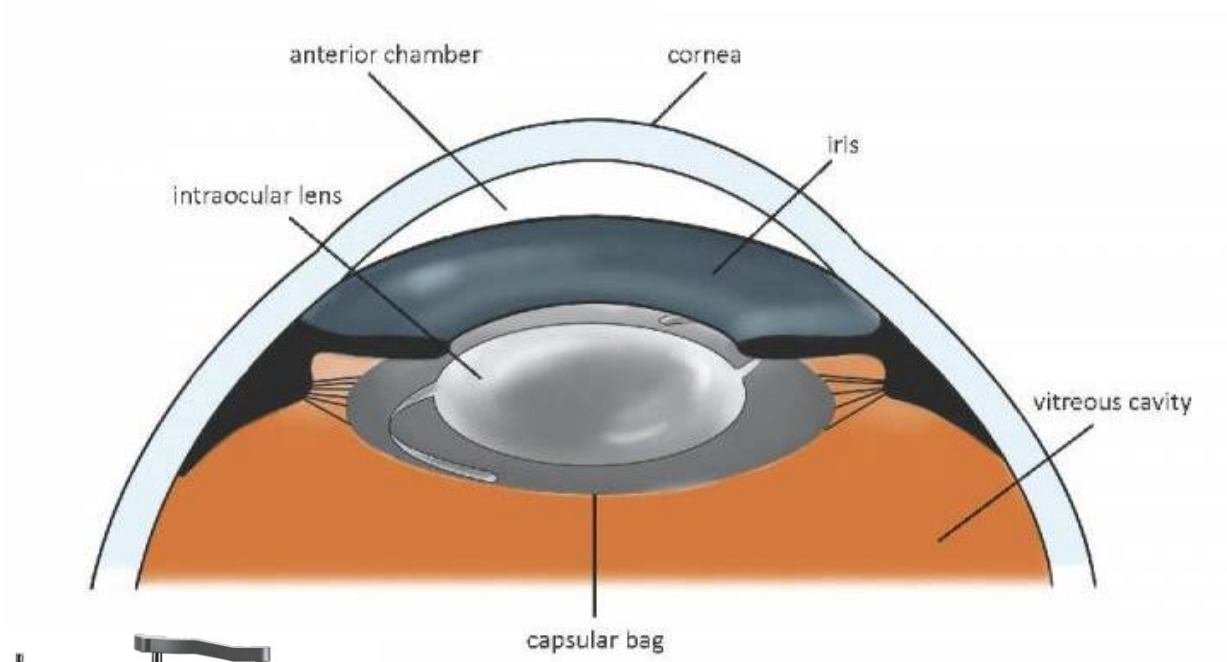
3. Intraocular Lens Implant: The artificial foldable intraocular lens is inserted and, once inside, the lens unfolds.

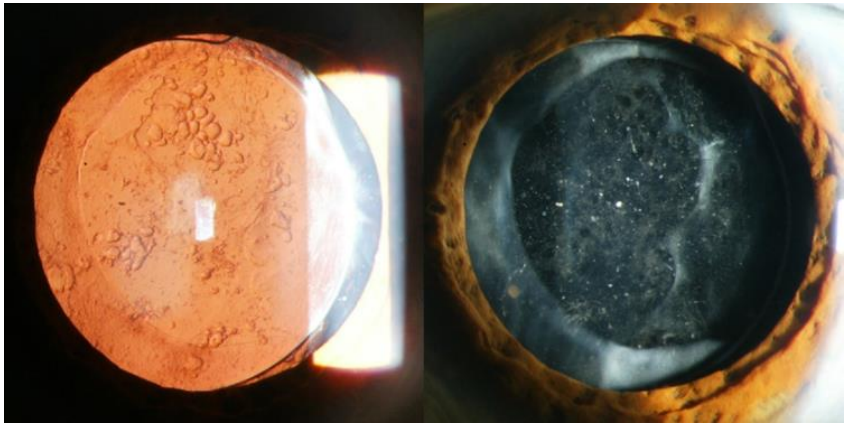


4. Result: The new lens is in place, the small incision heals naturally without the need for sutures, and vision is restored.

http://www.specialisteyecentre.com.au/patient-information/eye-conditions-surgery/cataract/

Correct posterior capsular opacification

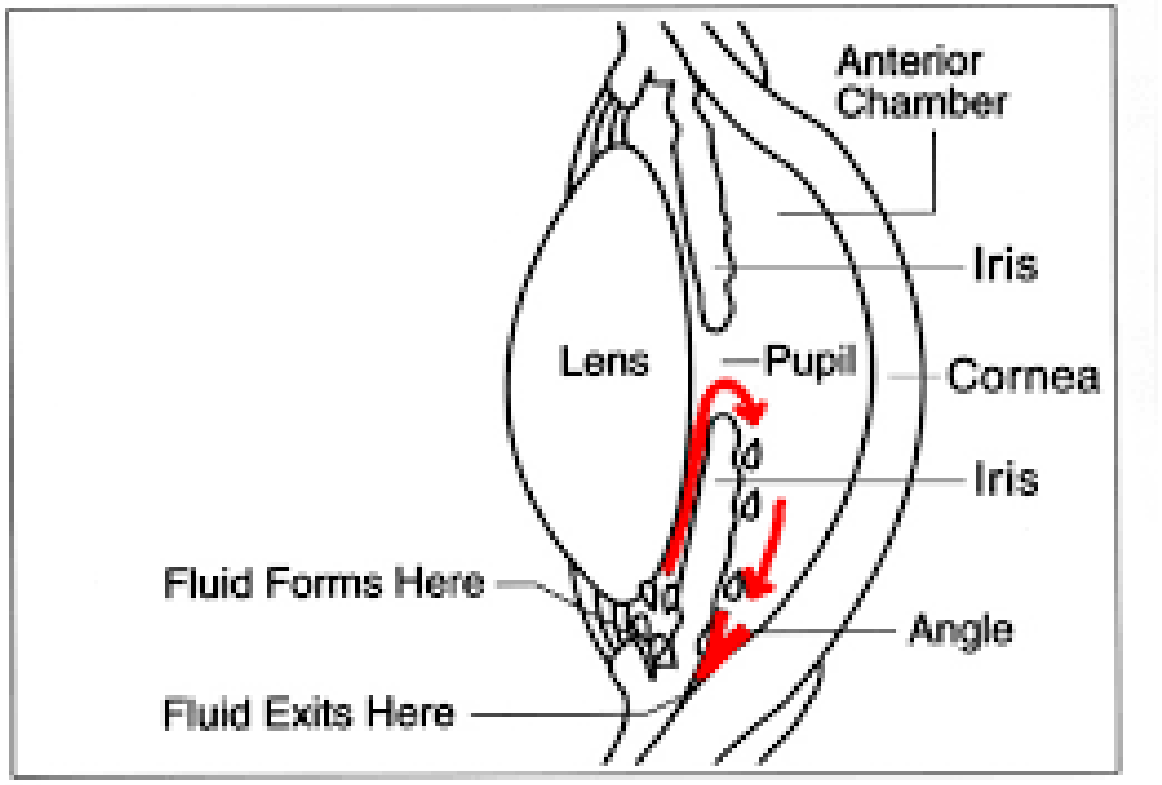




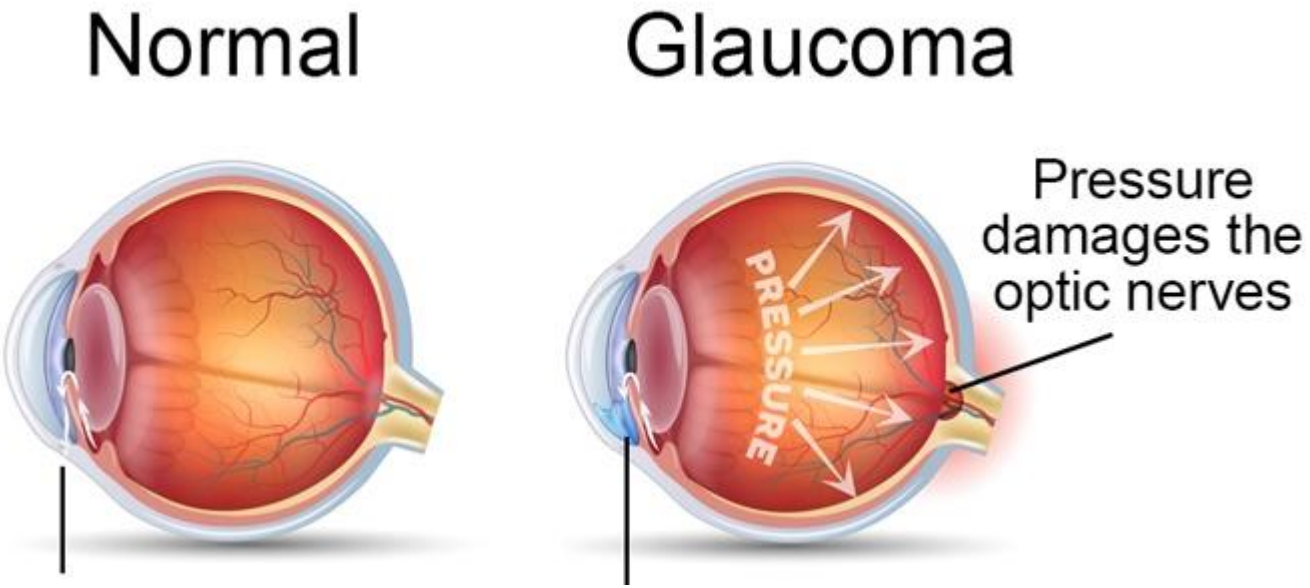
Intraocular fluid

-- intraocular fluid: aqueos humor and vitreous humor

-- maintain intraocular pressure

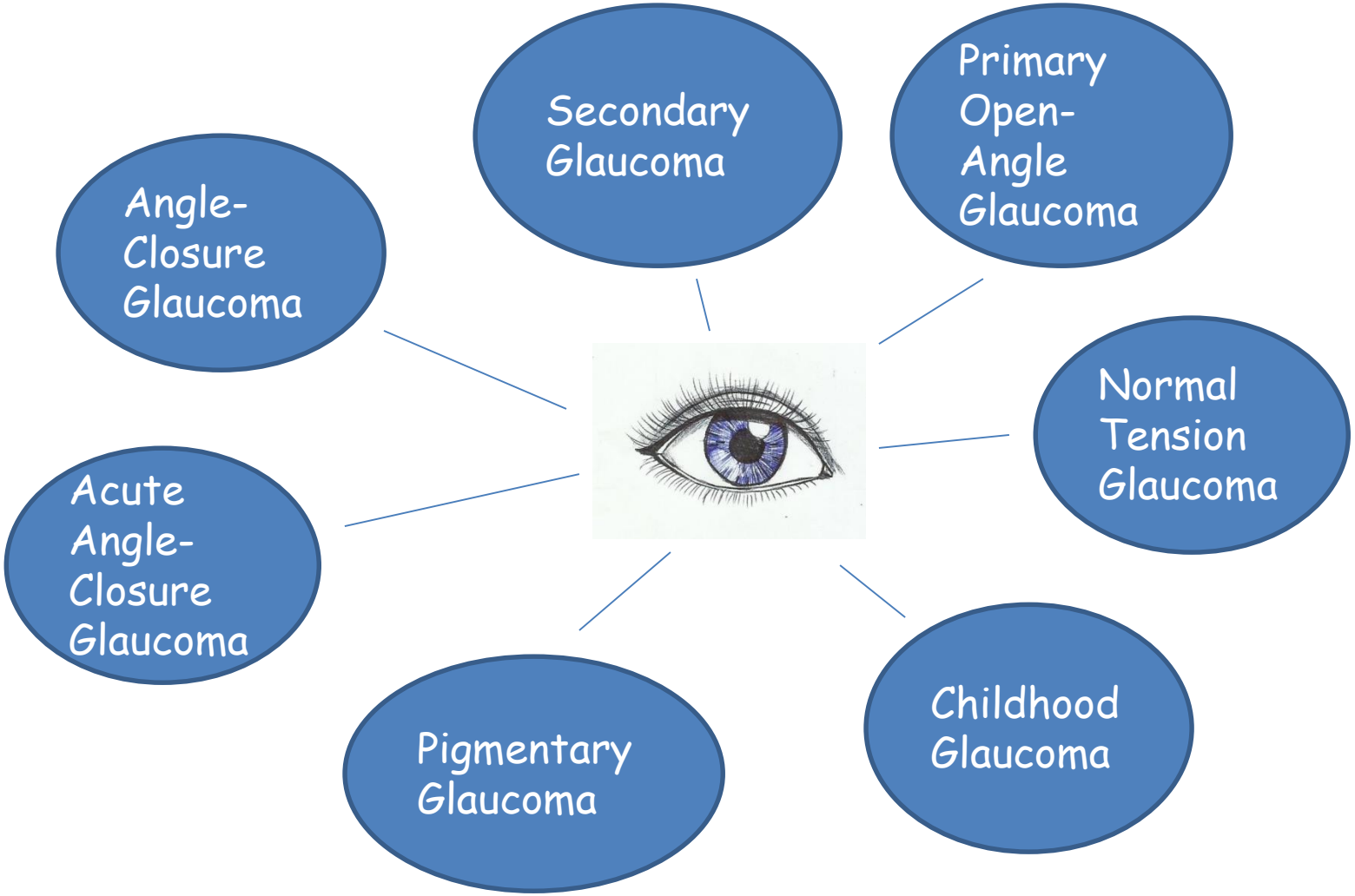


Glaucoma

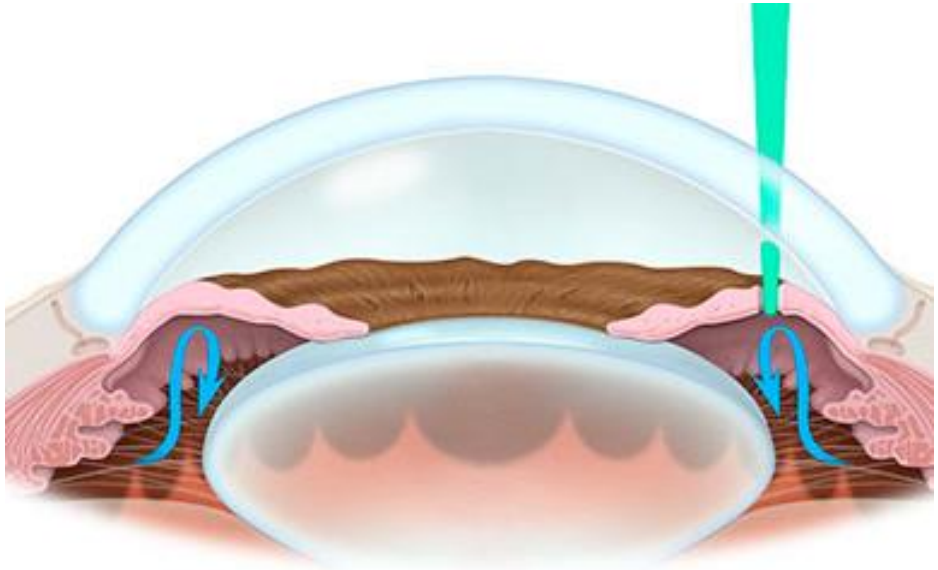


Abnormal liquid drainage or liquid production result in damage to the optic nerve and cause vision loss.

Types of glaucoma

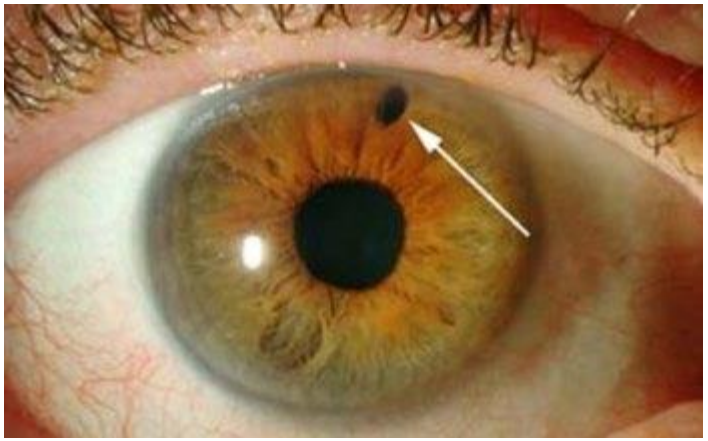


Angle- Closure Glaucoma

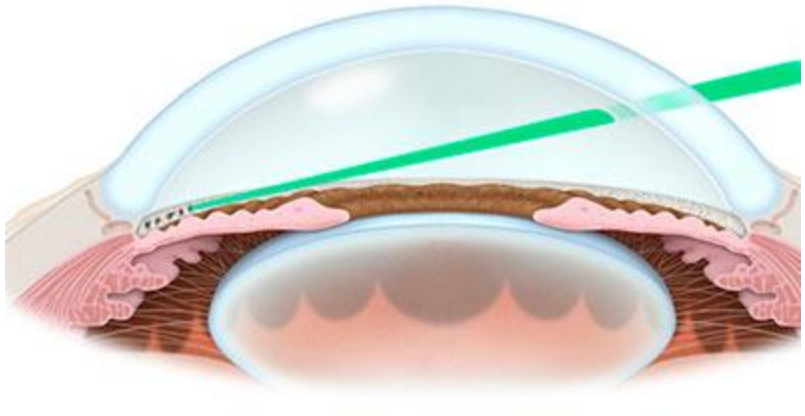


http://www.brandywineeye.com/our-services/glaucoma/laser-peripheral-iridotomy-ocular-hypertension-optical-coherence-tomography-selective-laser-trabeculoplasty

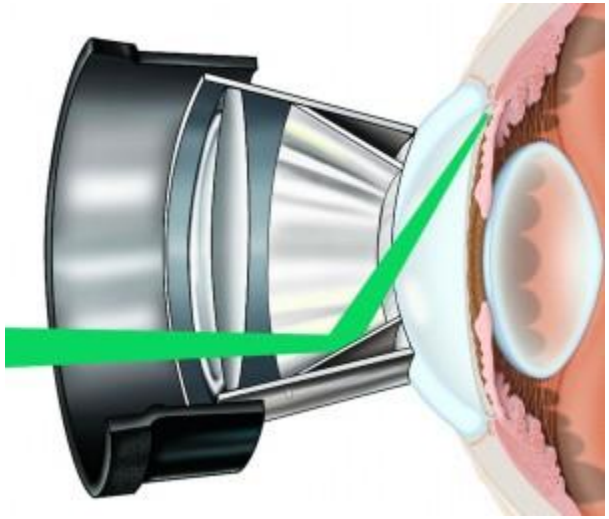
Peripheral iridotomy in patients with angle- closure glaucoma



Laser trabeculoplasty



http://www.brandywineeye.com/our-services/glaucoma/laser-peripheral-iridotomy-ocular-hypertension-optical-coherence-tomography-selective-laser-trabeculoplasty



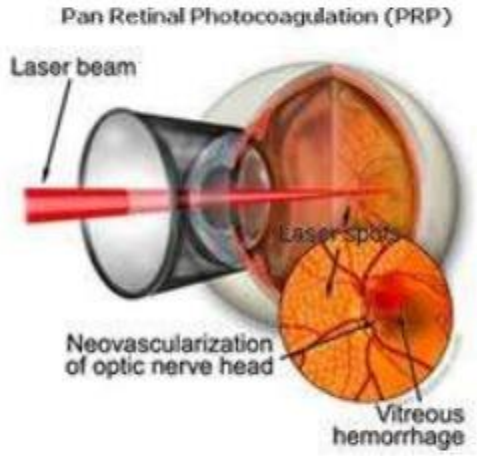
The targets are the pigmented trabecular meshwork cells in the angle of the eye.

Freqency doubled ND:YAG lasers pan-retinal photocoagulation (often termed as „ green laser)

Thermal Effects

Photocoagulation:

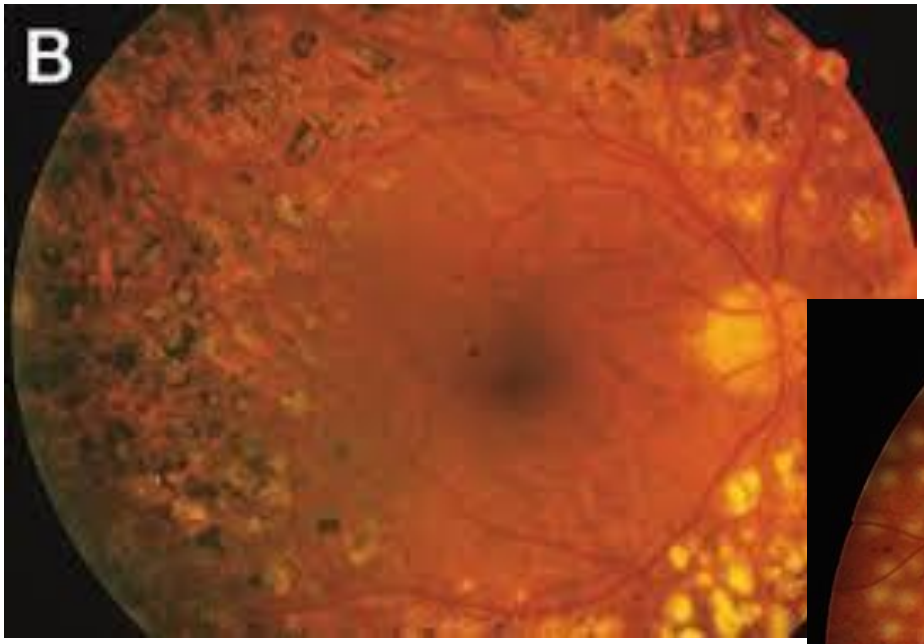
Laser Light
↓
Target Tissue
↓
Generate Heat
↓
Denatures Proteins (Coagulation)



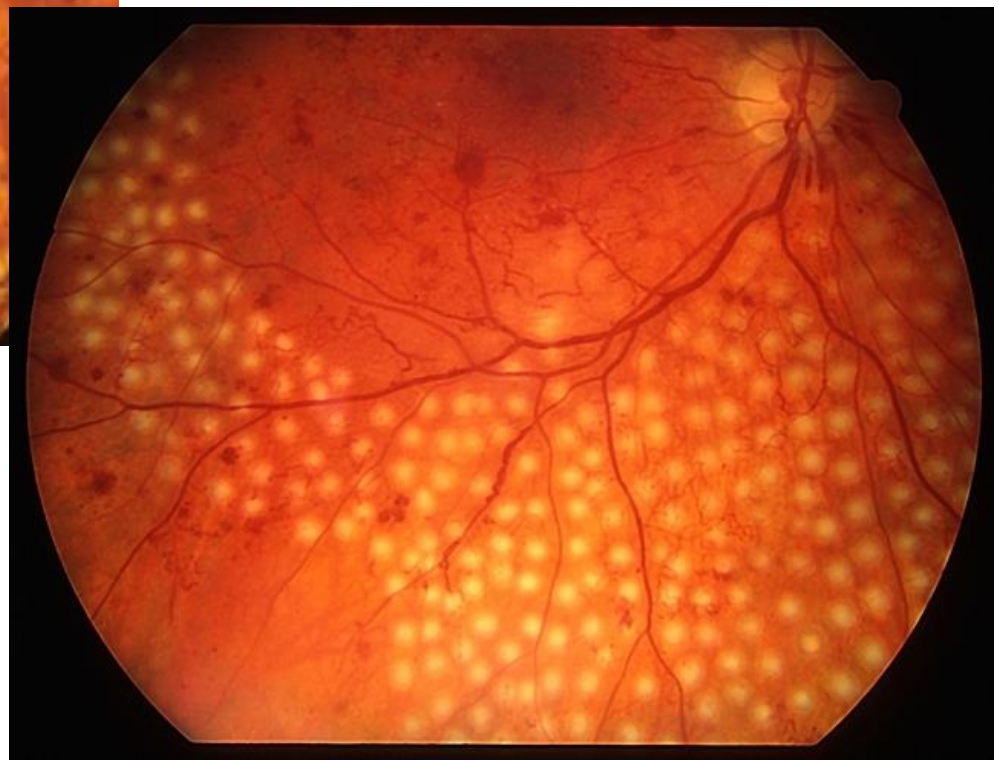
Rise in temperature of about 10 to 20 ^0C will cause coagulation of tissue. Frequency-doubled Nd:YAG lasers (wavelength 532 nm) are used for pan-retinal photocoagulation in patients with diabetic retinopathy. Argon and krypton lasers were used previously,

Highly absorbed by the hemoglobin and the melanin pigmnet.

Freqency doubled ND:YAG or Argon blue-green lasers pan-retinal photocoagulation



'Lasers essentially destroy tissue in order to have a beneficial effect on the eye'



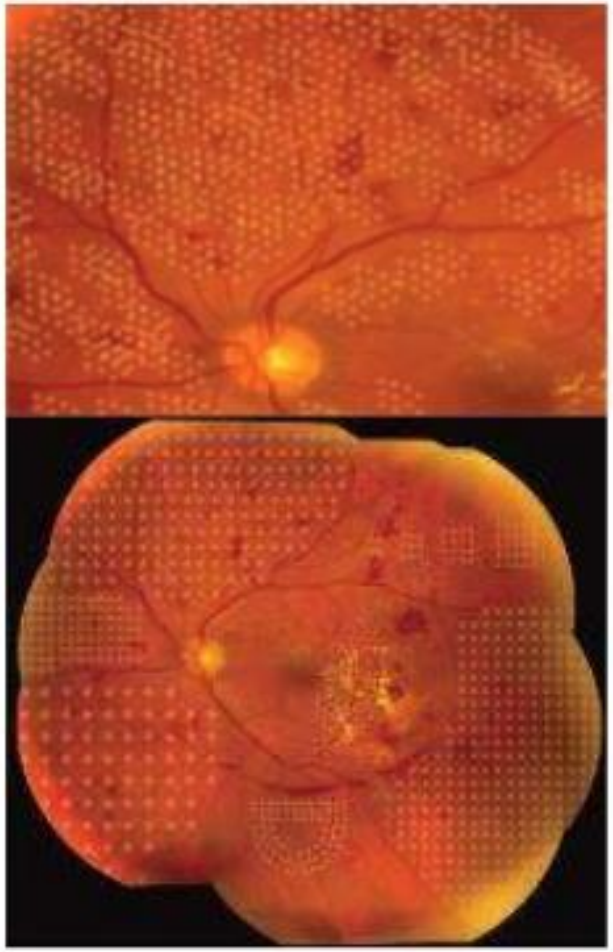
Argon blue-green laser (70% blue (488 nm) and 30% green(514nm)

LASER VARIABLE:

- Wavelength
- Spot Size
- Power
- Duration

Pattern scan laser (PASCAL)

- The PASCAL Photocoagulator is an integrated semi-automatic pattern scan laser photocoagulation system designed to treat ocular diseases using a single shot or multiple shots at a single click to predetermined pattern array.
- Laser source :Nd:YAG laser (green or yellow)
- Delivery device: slit lamp or laser indirect ophthalmoscope (LIO)
- It has Control system for selecting power , duration and spot size
- It also has micropulse technology to deliver sub threshold burns by reducing the duty cycle and thus less damage to tissue & less heat production in macular area
- Used for PRP and macular lasers



https://www.slideshare.net

Retiniopathy prematurity (ROP)

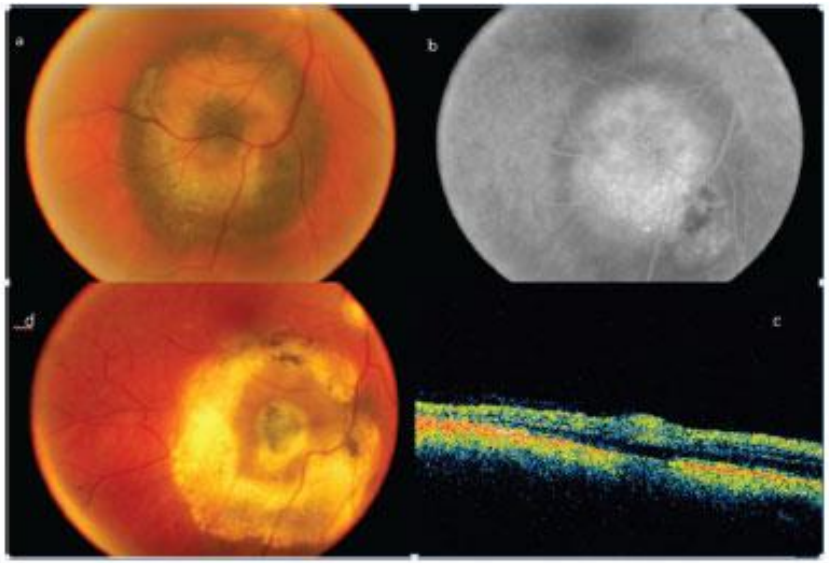
- birth of a baby at fewer than 37 weeks gestation age
- disorganized growth of retinal blood vessels
- new vessel formation

Dioda laser (805-810 nm)

- well absorbed by melanin
- near infrared spectrum
- very deep penetration

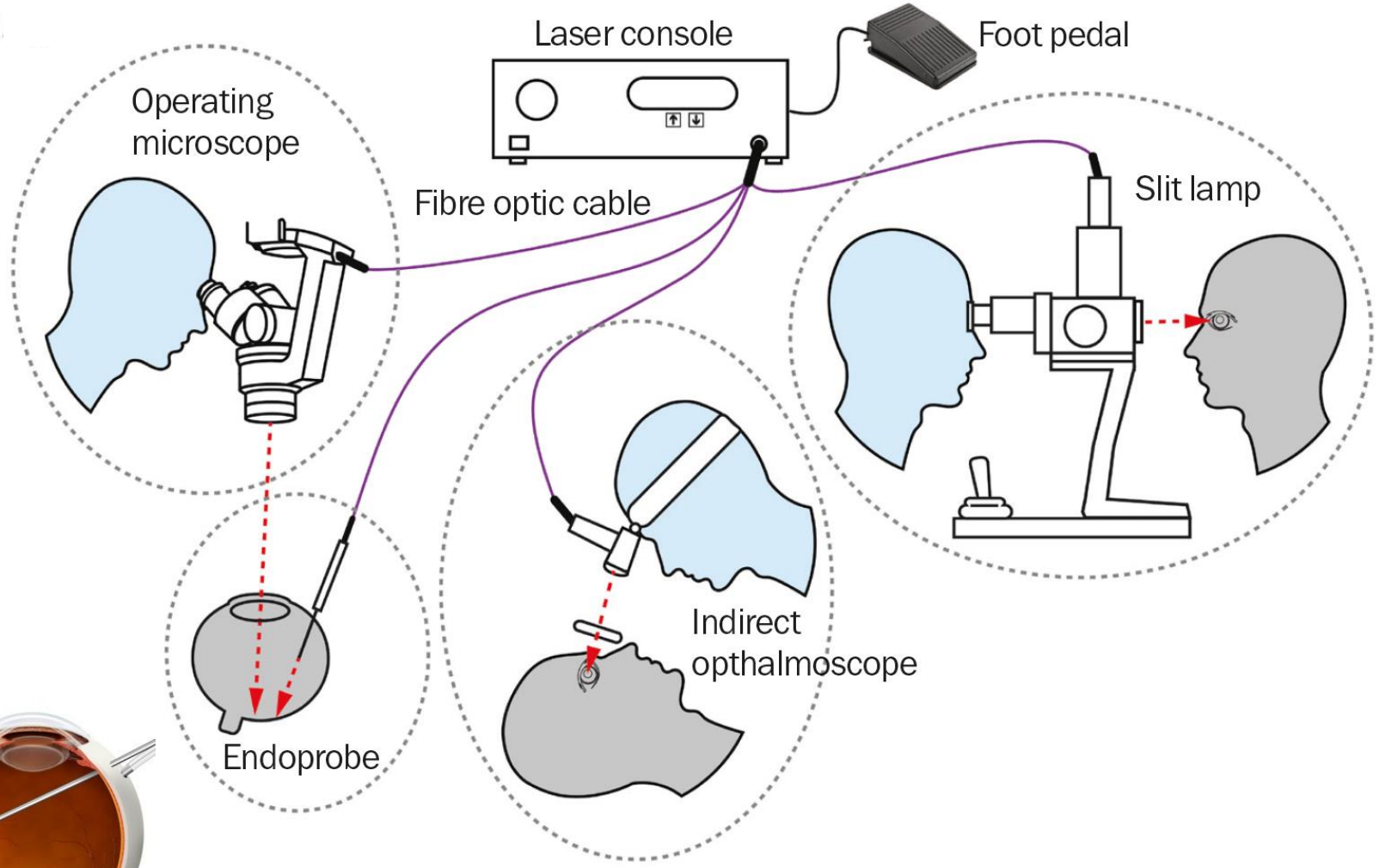
Transpupillary thermotherapy (TTT)

- Transpupillary thermotherapy is proven and medically necessary for treating the following tumors :
  - Retinoblastoma
  - Choroidal melanomas

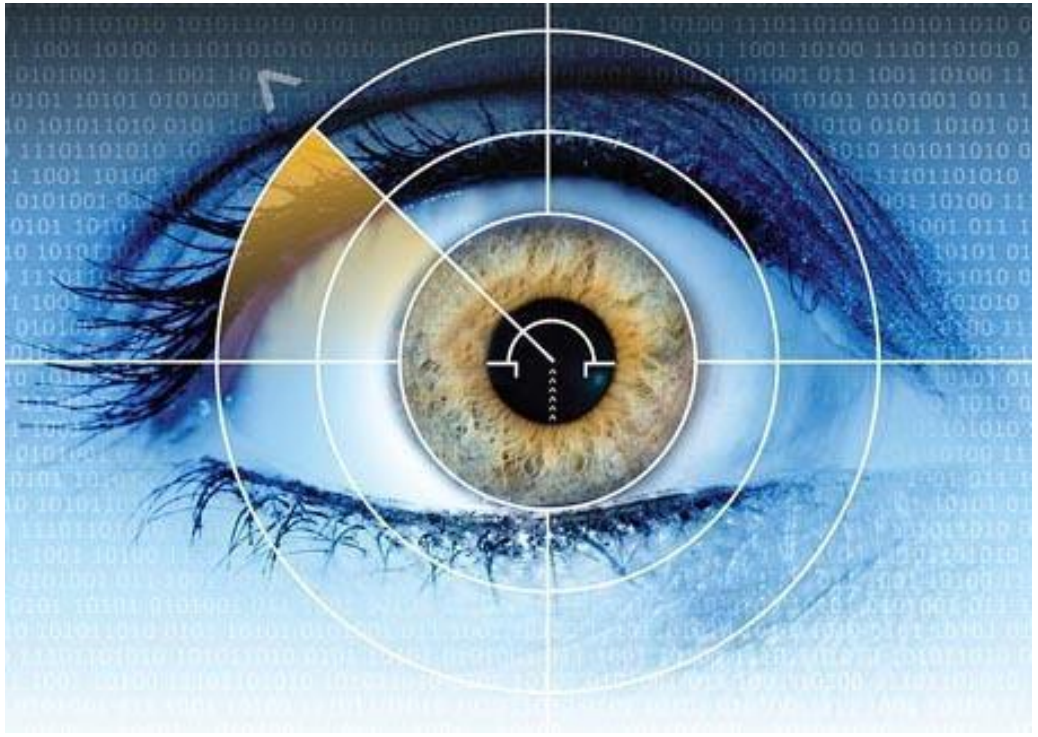


- diode laser to raise the temperature within treated tumor tissue, causing heat-induced sclerosis of vascular channels and eventually tumor regression and resolution of subretinal fluid.

Main components and different delivery systems of a laser



An **excimer laser** is a powerful kind of **laser** which is nearly always operated in the **ultraviolet** (UV) spectral region (→ ***ultraviolet lasers***) and generates nanosecond **pulses**.



Refractive surgery

- **Refractive eye surgery** is an eye surgery used to improve the refractive state of the eye and decrease or eliminate dependency on glasses or contact lenses.
- This can include various methods of surgical remodeling of the cornea (keratomileusis).
- The most common methods today use excimer lasers to reshape the curvature of the cornea.
- Successful refractive eye surgery can reduce or cure common vision disorders such as myopia, hyperopia and astigmatism, as well as degenerative disorders like keratoconus.

Refractive Surgeries

- Photorefractive keratectomy
- Laser subepithelial keratomileusis (LASEK)
- Laser-assisted *in situ* keratomileusis (LASIK)

Diagnostic application of lasers

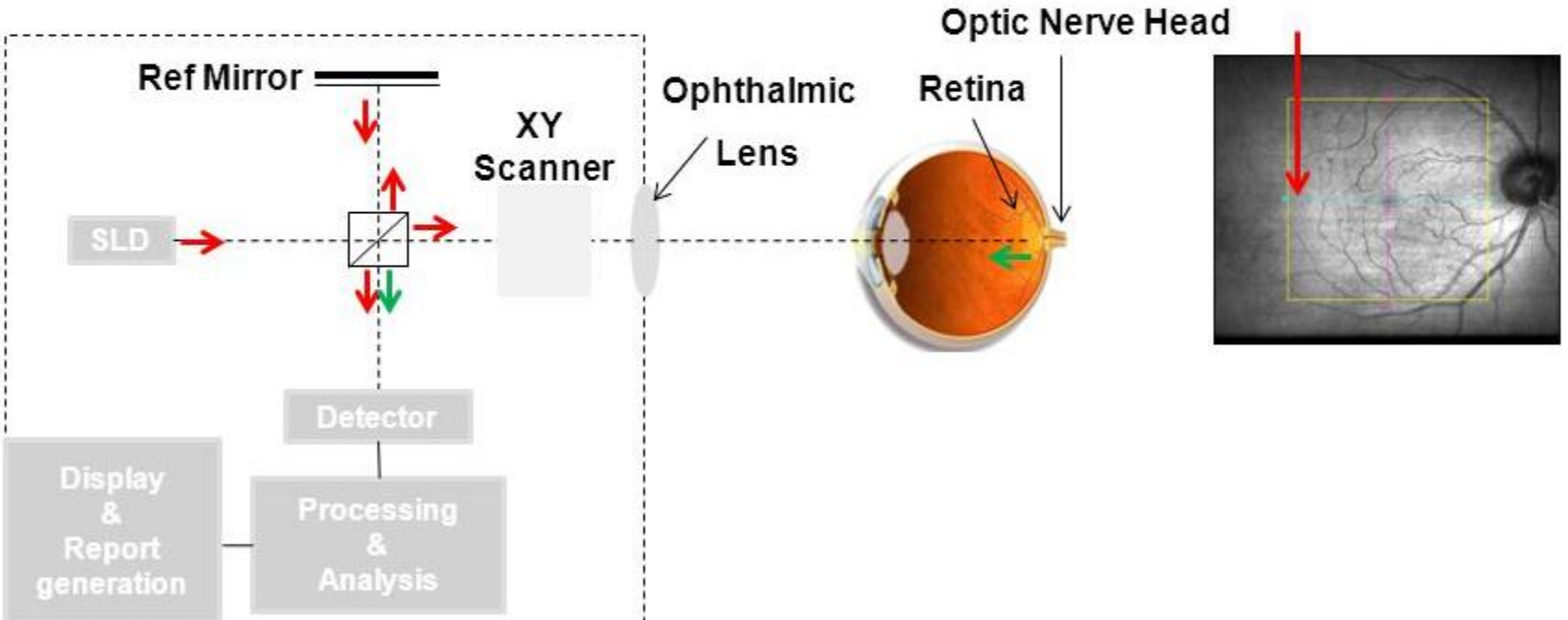
- Optical coherence tomography OCT
  - anterior segmen
  - posterior segment

- Optical coherence tomography angiography OCTA
- Optomap system

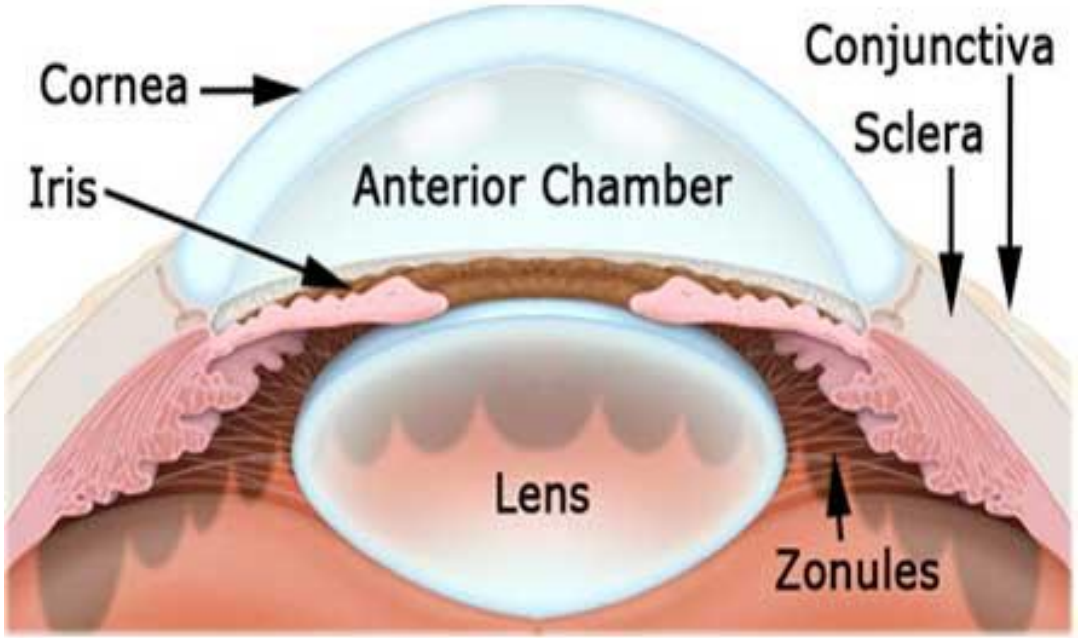
How does OCT work ?

OCT is a non-invasive, sub-surface imaging technique capable of providing high resolution cross sectional images of biological tissues such as retina.

OCT empowers you with the details of "What lies beneath the fundus image?"

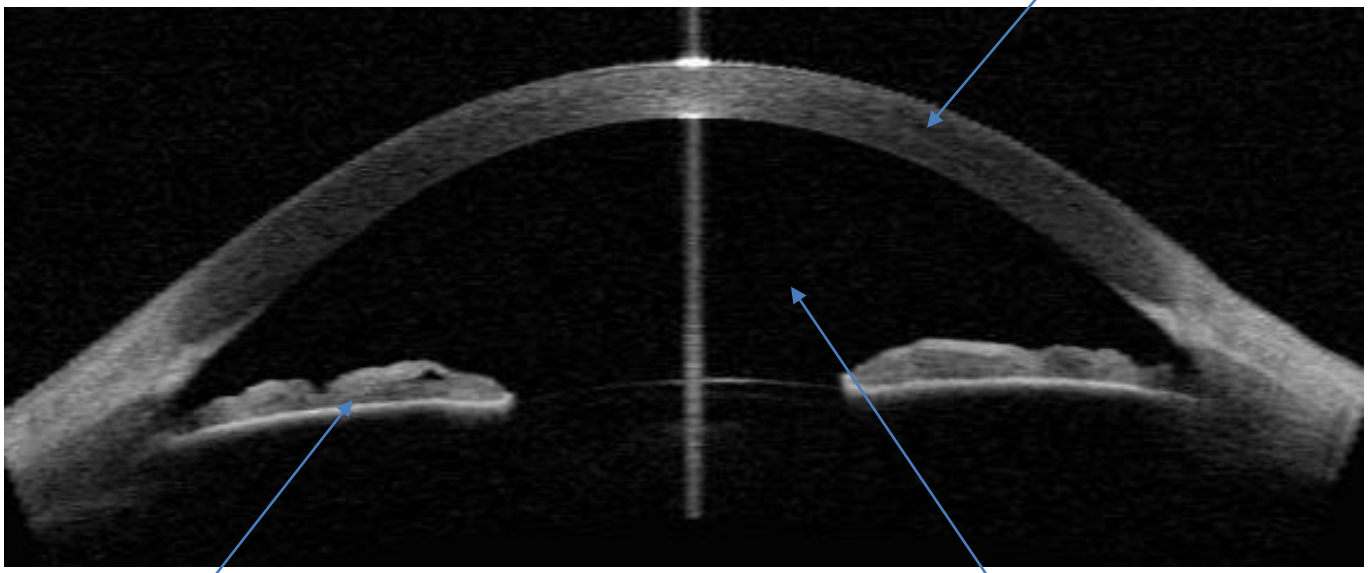


Anterior segment of the eye



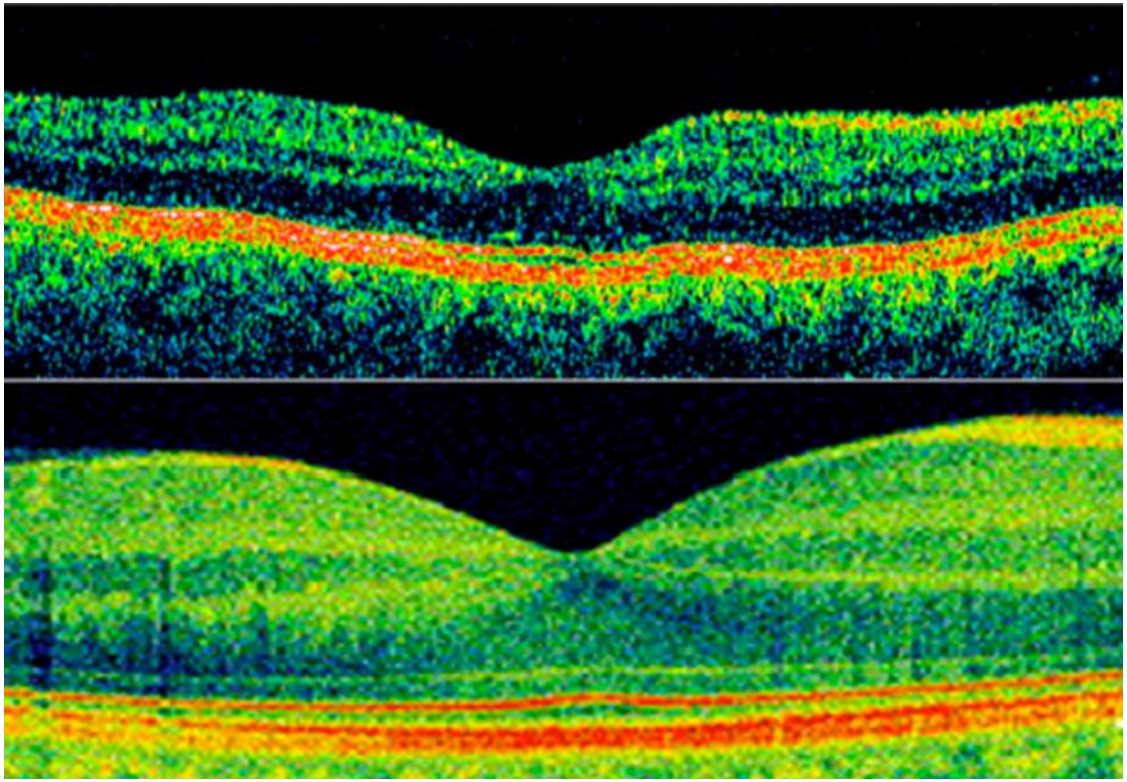
http://visioncareonline.in

Anterior OCT image

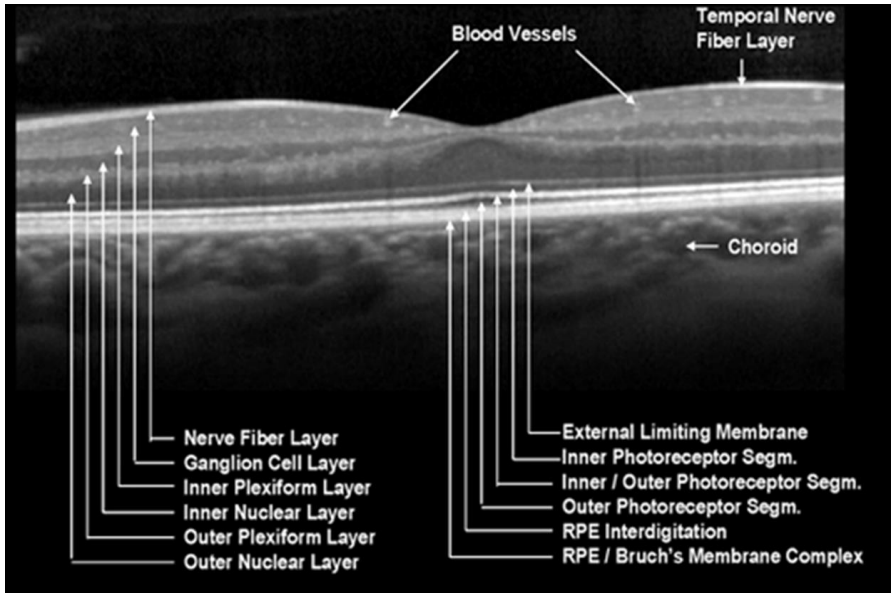


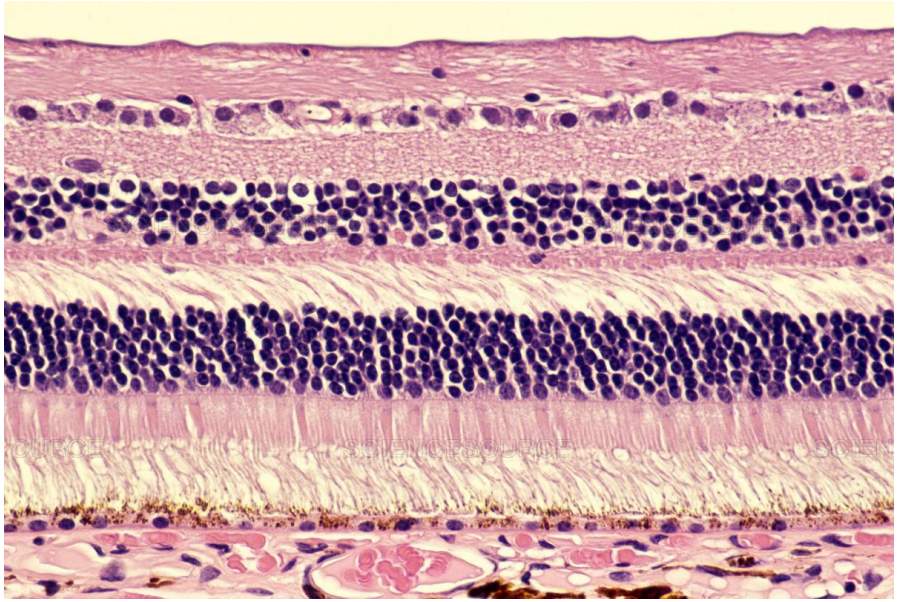
Measuerements : cornea thickness
cornea anterior radius
anterior chamber depth
irido corneal angle

Time domain and Spectral domain OCT



Retinal labeled layers



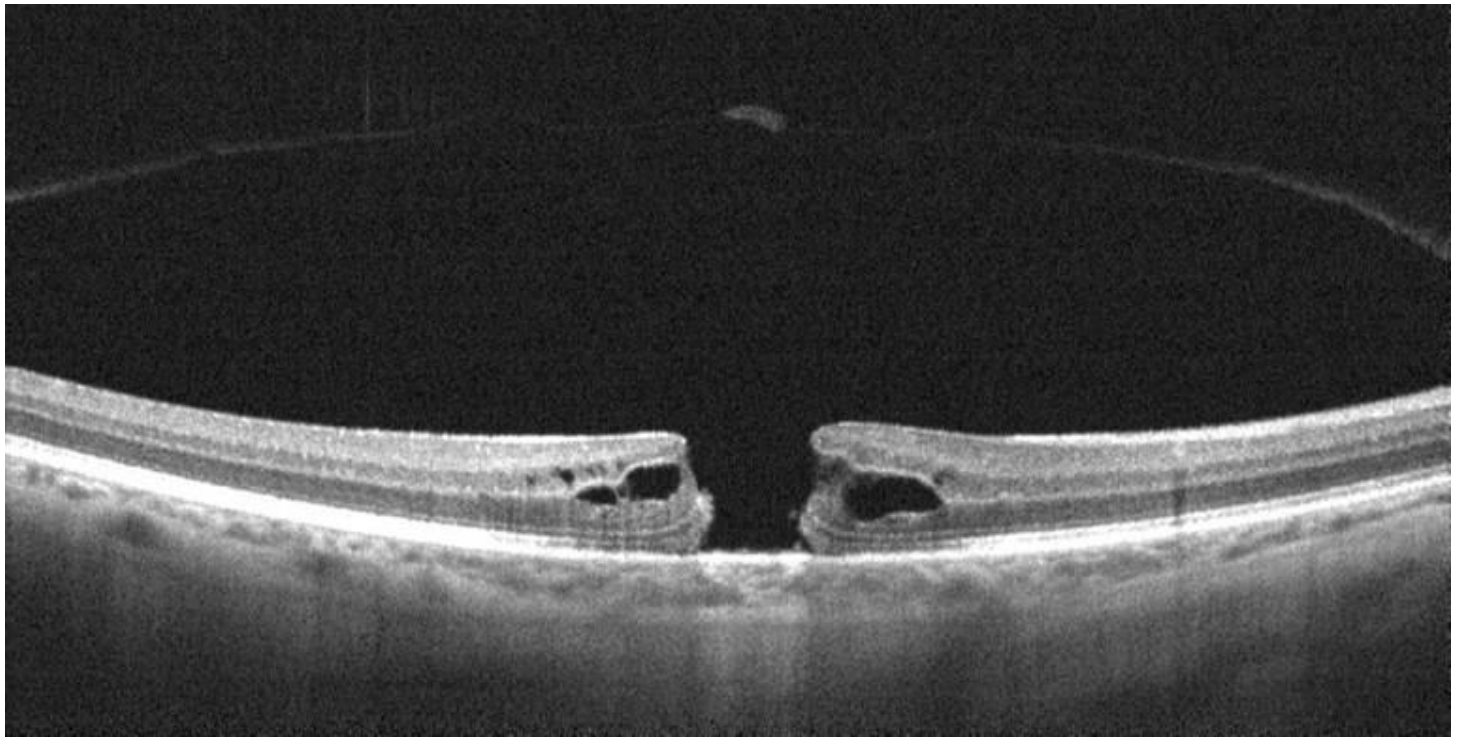


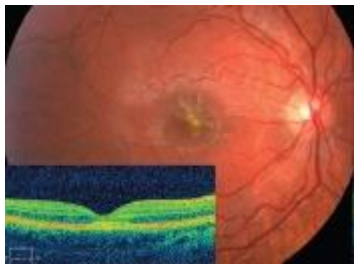
What conditions can OCT help to diagnose?

OCT is useful in diagnosing many eye conditions, including:

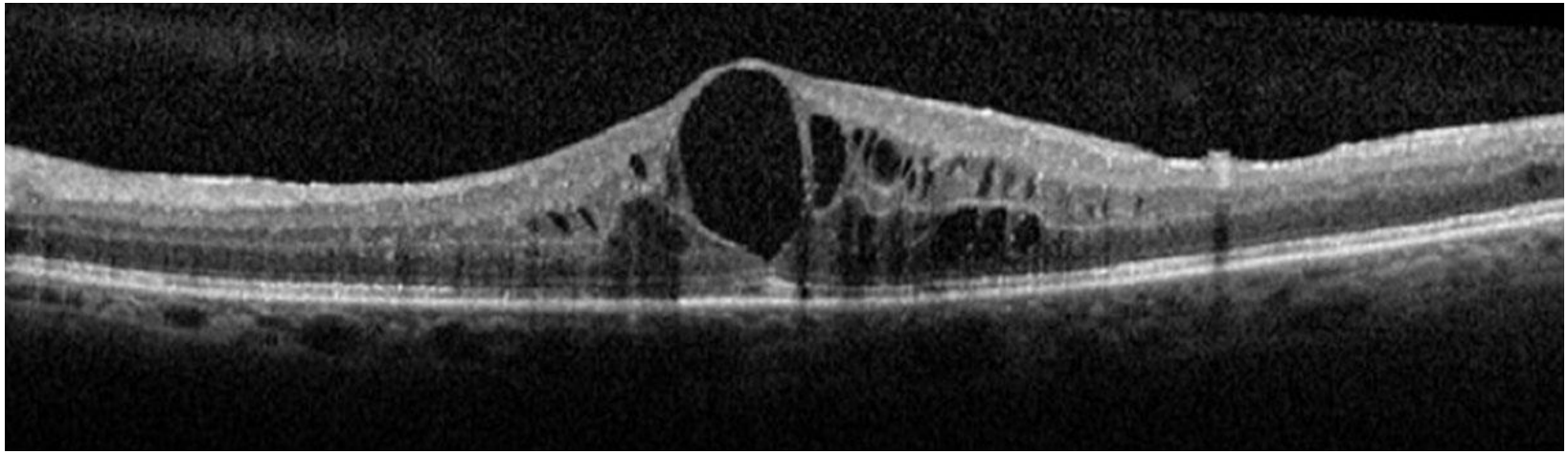
- macular hole
- macular pucker
- macular edema
- age-related macular degeneration
- glaucoma
- central serous retinopathy
- diabetic retinopathy
- vitreous traction

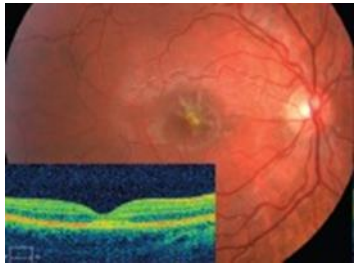
Macular hole



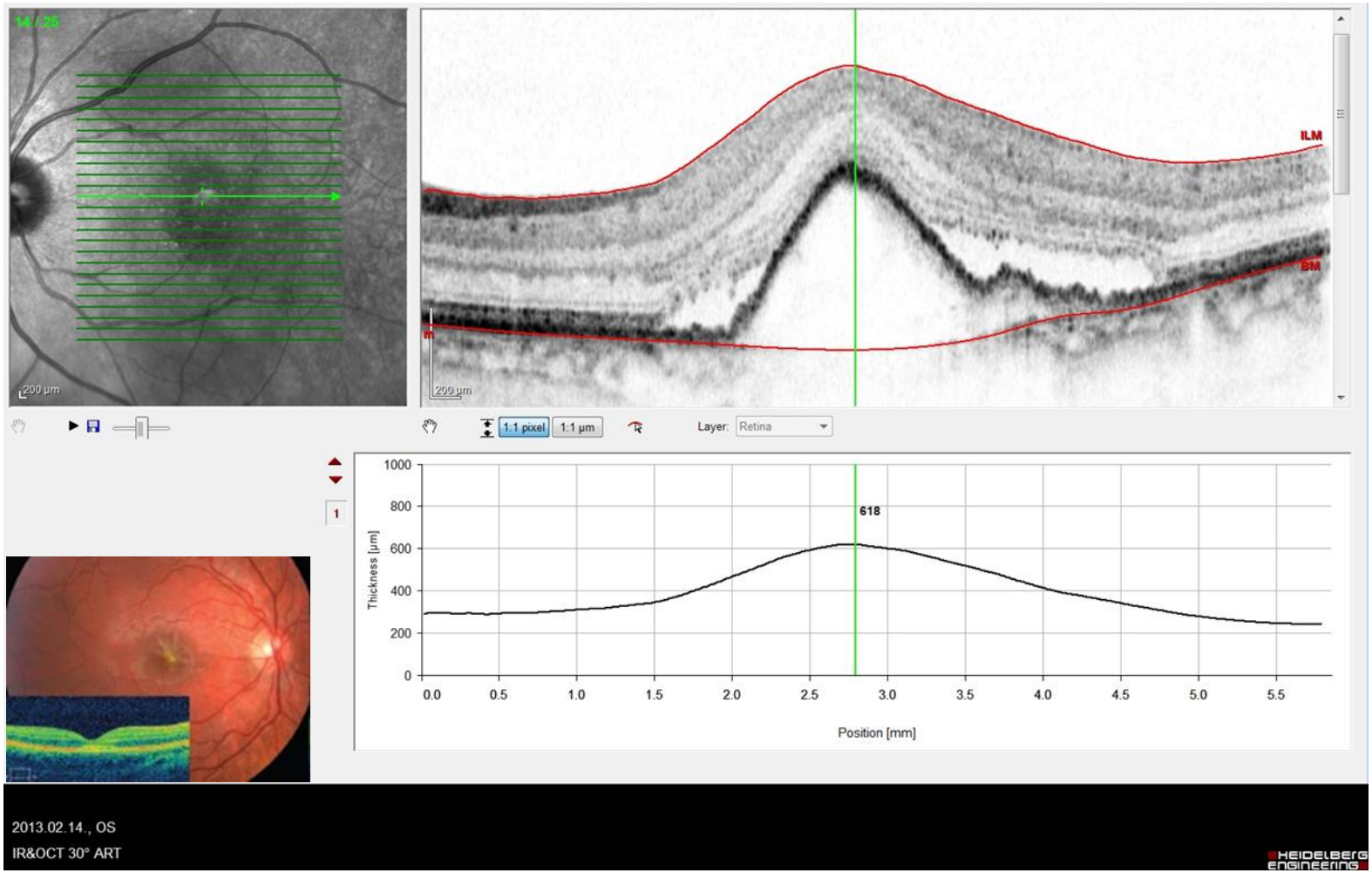


Macular oedema

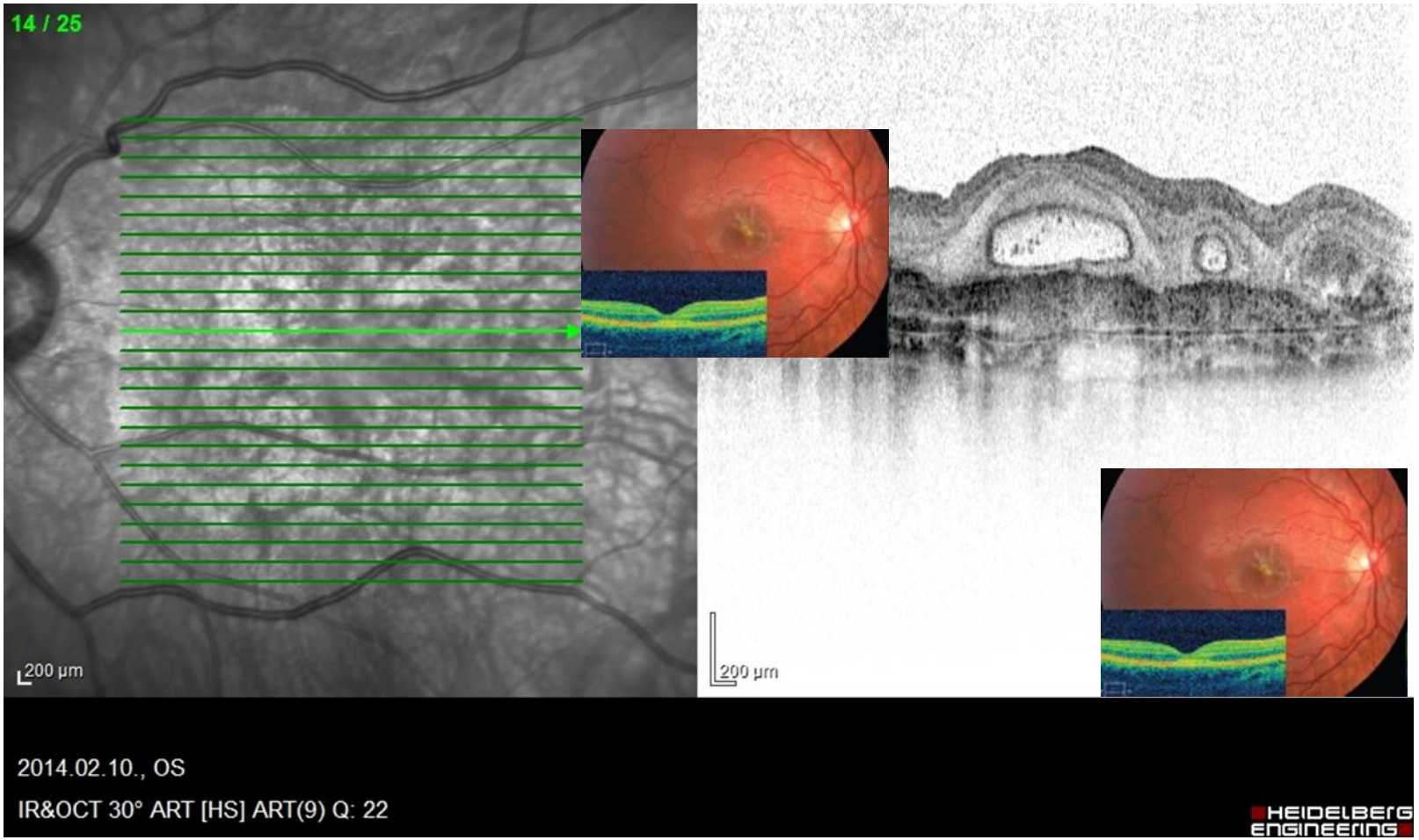




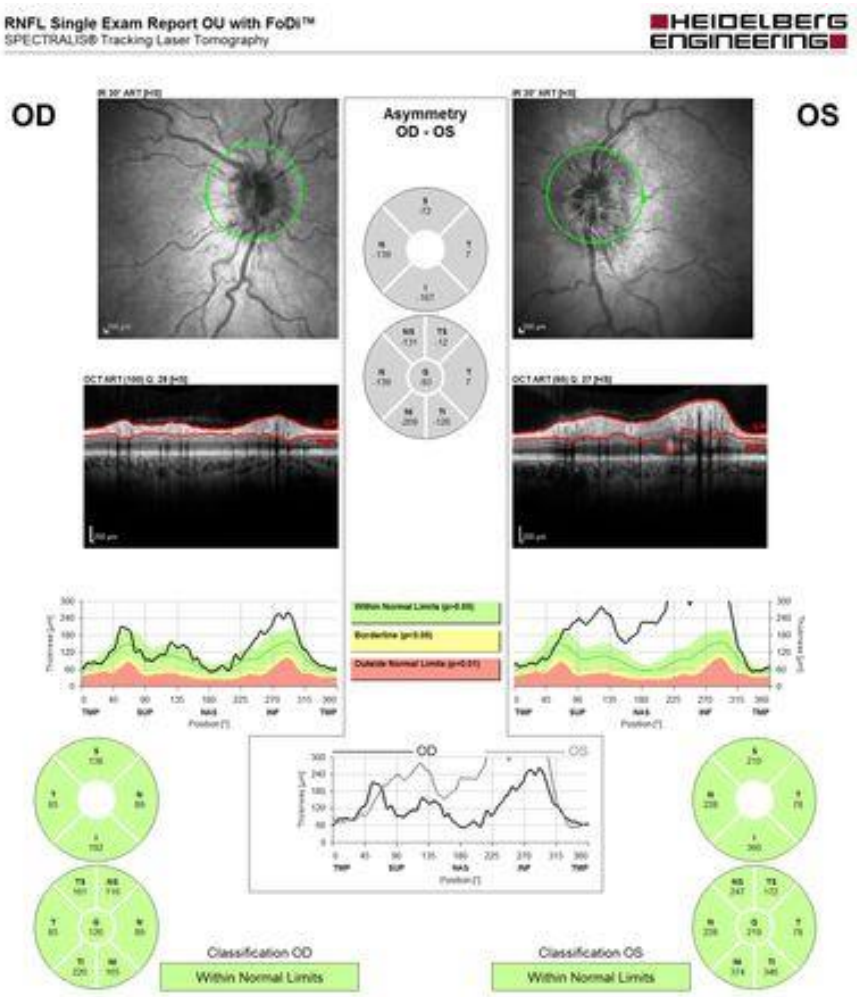
Age related macular degeneration



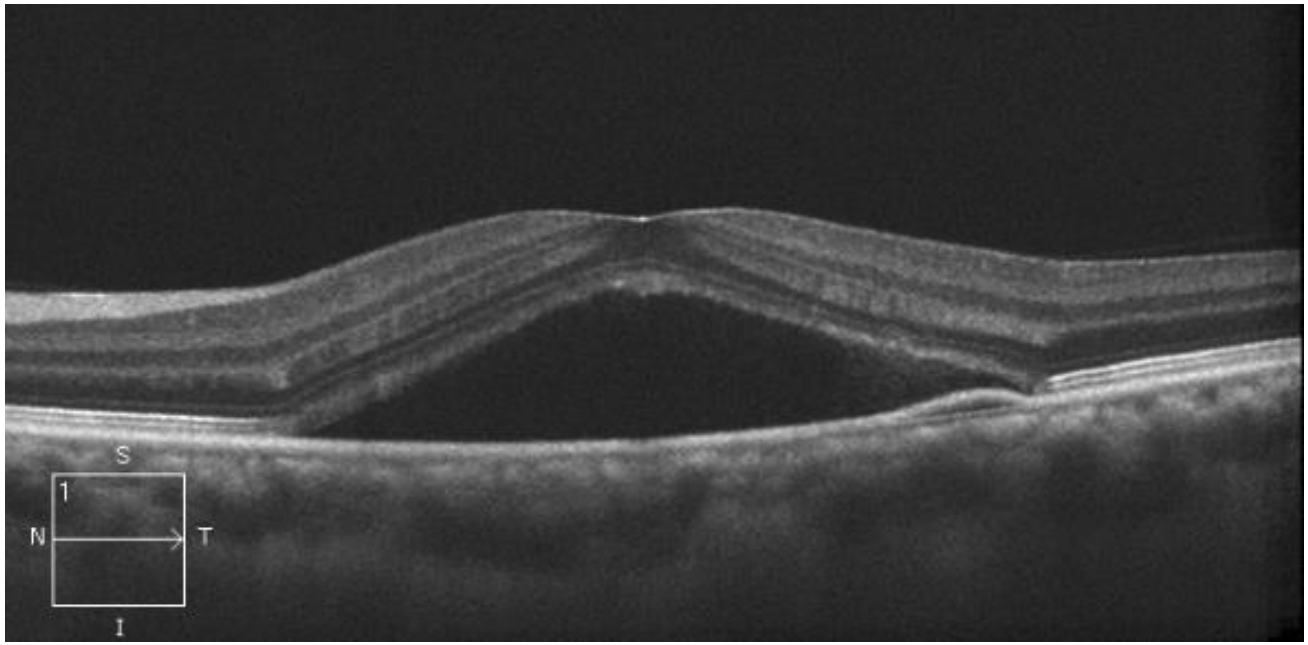
Age related macular degeneration



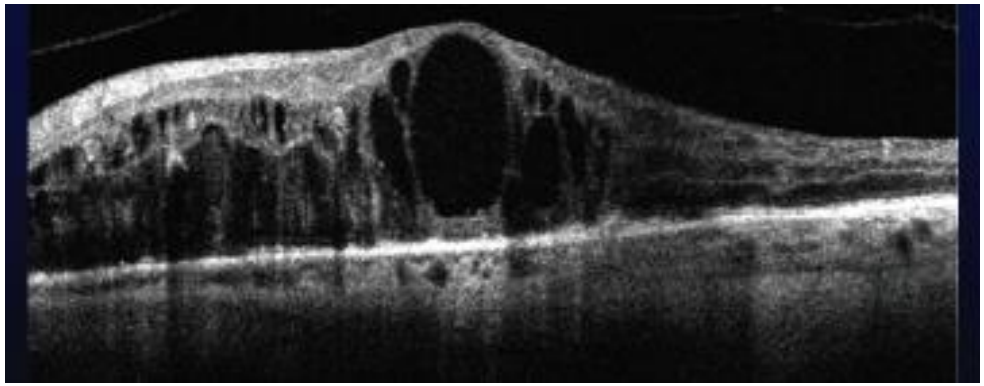
Optic nerve analyser

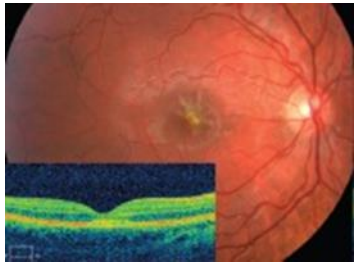


Central serous chorioretinopathy

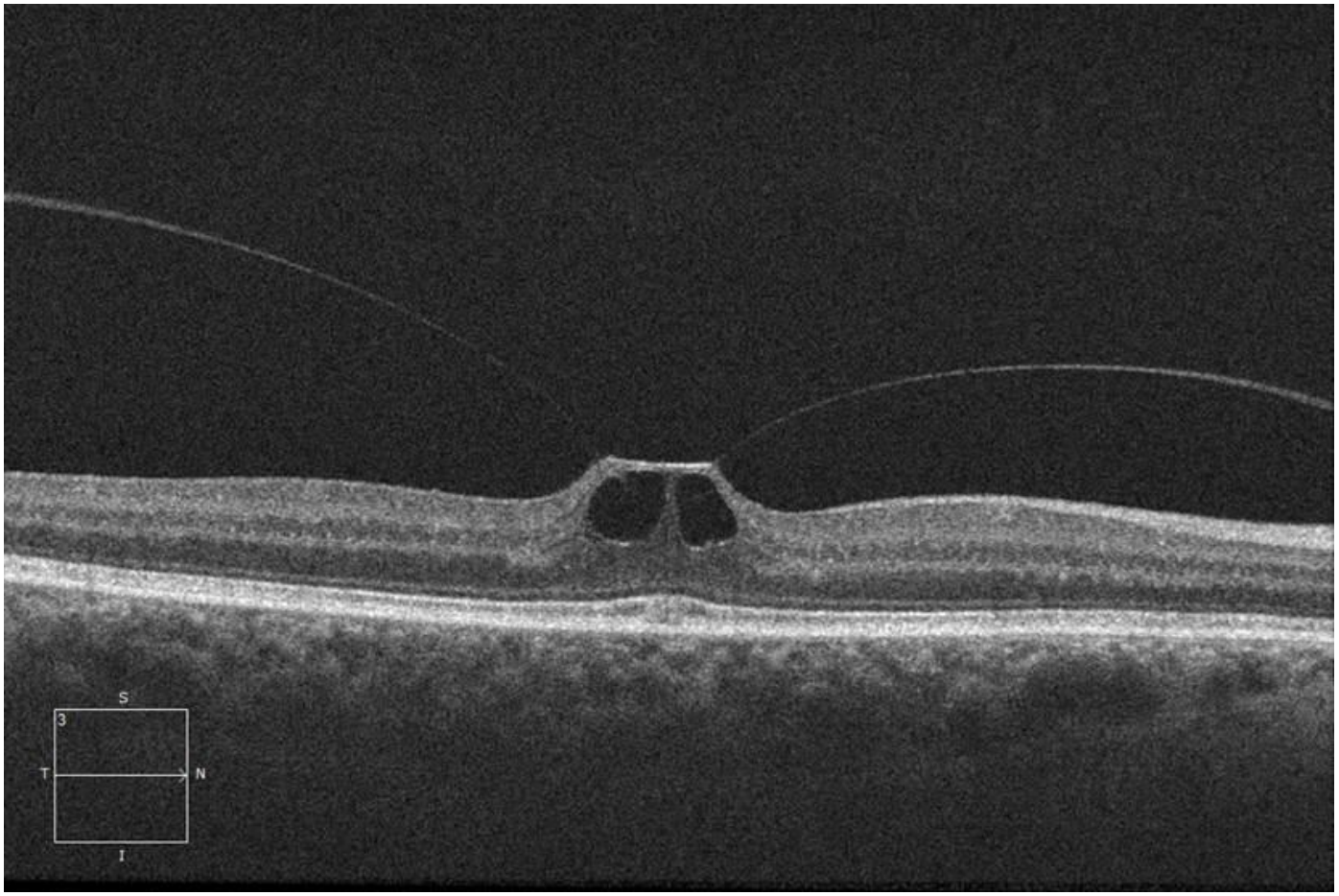


Diabetic retinopathy





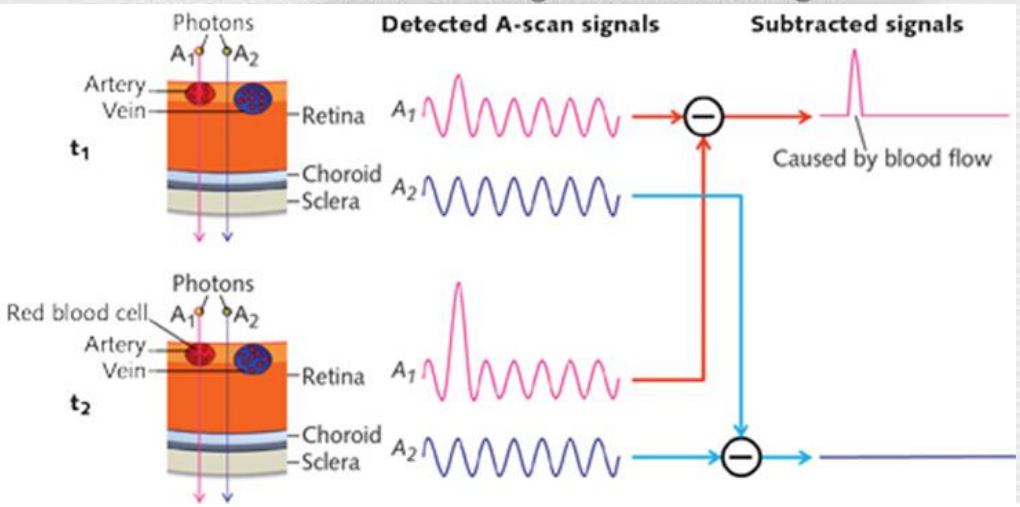
Vitreo-macular traction



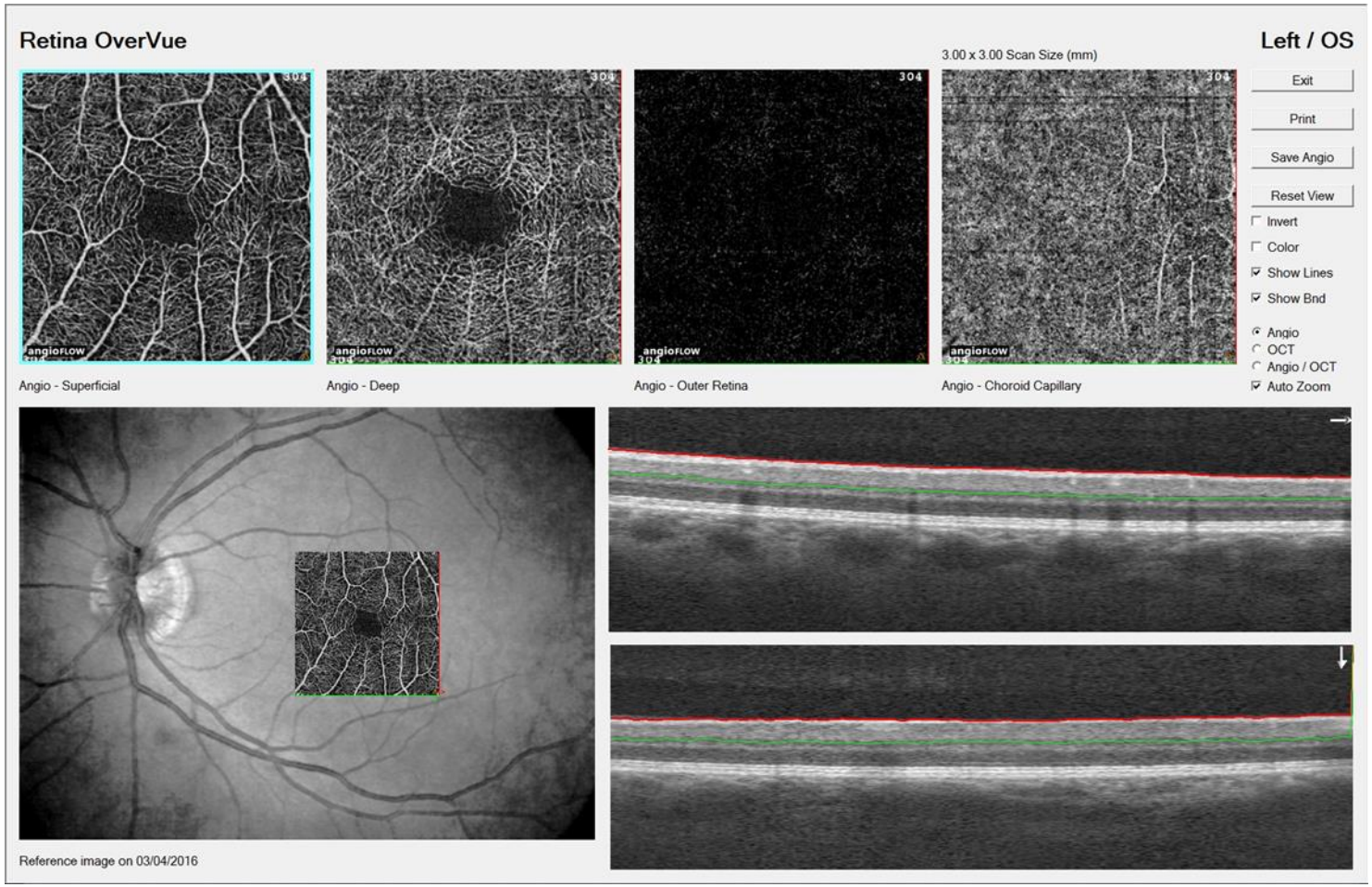
How does OCT-A work?

OCT image is a structural, cross-sectional, B-scan image.

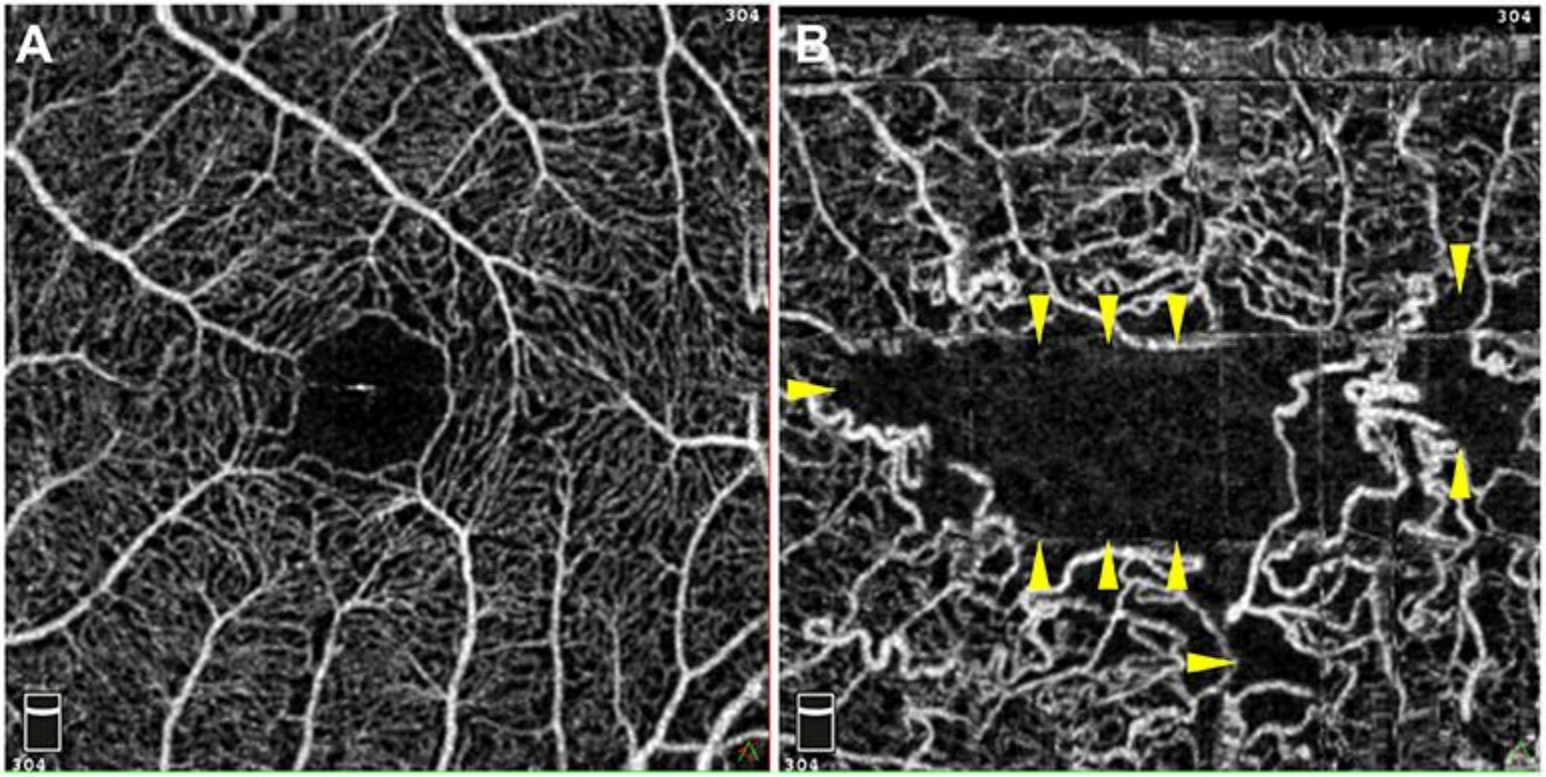
OCT works by sending a **long-wavelength light**, then detecting changes that occurred on the tissue-reflected light; thereby, it converts the reflected light into an image.



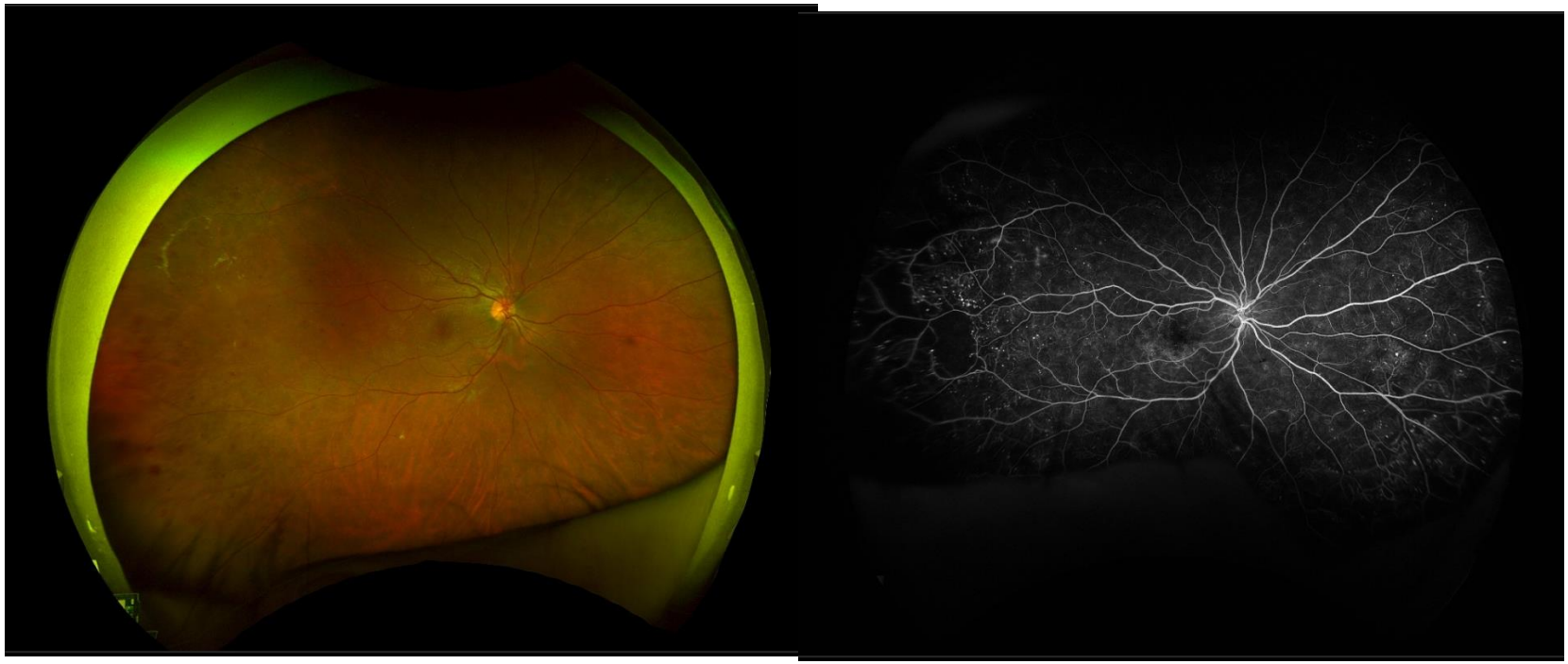
Optical Coherence Tomography Angiography (OCTA)



OCTA diabetic retinopathy



OPTOS



optomap technology incorporates low-powered laser wavelengths that scan simultaneously.
Green laser (532 nm) scans from the sensory retina to the pigment epithelial layers
Red laser (633 nm) scans from the RPE to the choroid
Blue laser (488 nm) used in fluorescein angiography procedures
Infrared laser (802 nm) used in indocyanine green angiography procedures


Thank you for your attention