590 nm 660 nm 850 nm

From Photon to Photoreceptor

The Science and Clinical Application of Light Therapy in Eye Care

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September 22, 2026 · COPE Course ID: [pending] · 2.0 CE Hours

Financial Disclosures

- Consultant / Speakers Bureau: [None]
- Research Support / Investigator: None]
- Equity / Ownership Interest: [None]
- Royalties / Intellectual Property: [None]

"All relevant relationships have been mitigated."

- This course is COPE-accredited and free of commercial bias.
- Off-label / investigational uses — photobiomodulation for diabetic macular edema, retinitis pigmentosa, glaucoma, and myopia control — will be explicitly identified as such when discussed.
- Trade names are used only where required for clinical clarity; competing technologies are presented where they exist.

Dedicated to Advancement and Clinical Excellence

- 5 Locations
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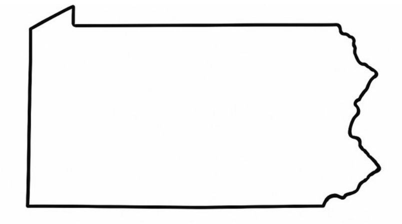
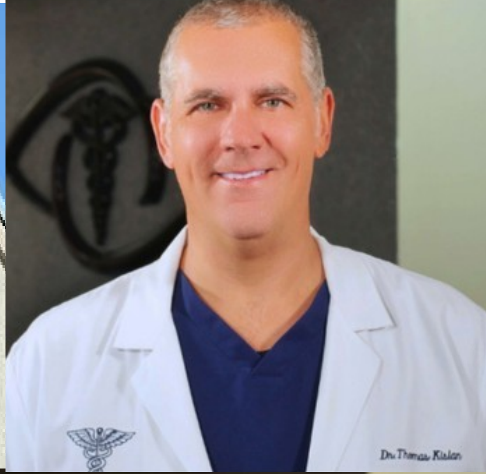
- Continue to innovate and bring new treatments



Hazleton Eye Specialists



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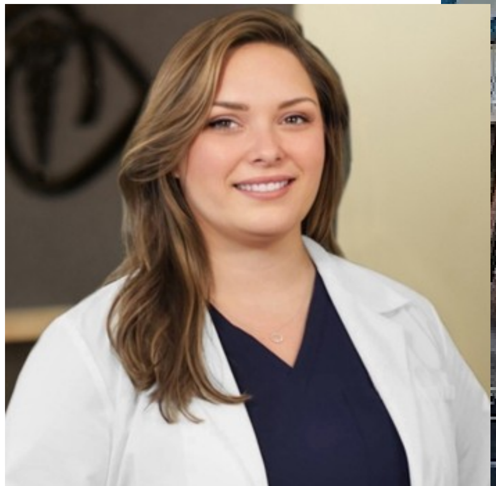

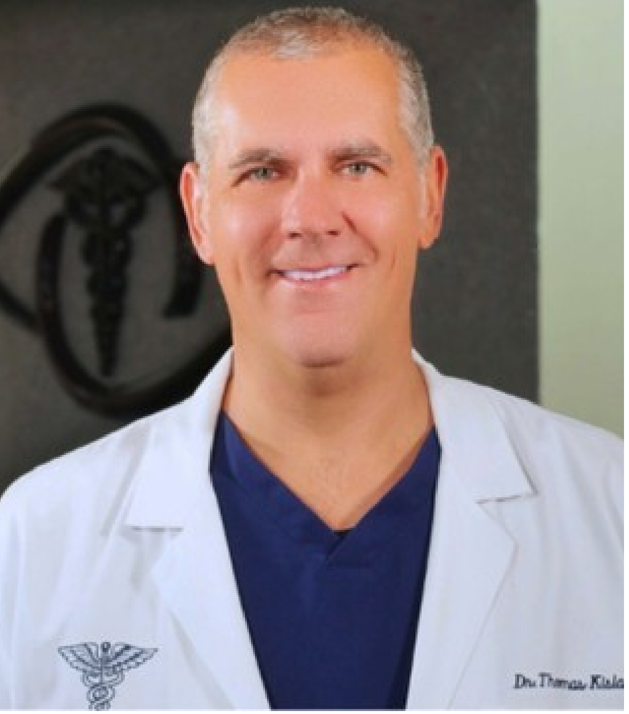

Stroudsburg Eye Specialists

BANGOR
EYE SPECIALISTS

385 Bangor Junction Rd.
Bangor, PA 18013
Phone: 610-588-0129

Nanticoke Eye Specialists

- Conveniently located in the Wyoming Valley
- Specializing in Brain Injury and Vision Development
- Comprehensive Eye Care
- Retinal Specialty Care – injections, lasers

245 S. Prospect St.
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Phone: 570-735-6000
Fax: 570-735-5300

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  Pottsville, PA 17901
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BRIGHT
EYES & FACE
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2 Locations,
1 Medical Director
2 Pas, 3 CRNPs, 1 RN, 2 Front Desk

Bedford through the years

COURSE OBJECTIVES

Learning Objectives

1 Describe the mechanisms

Chromophore absorption by cytochrome c oxidase, mitochondrial ATP production, ROS and inflammatory modulation, and wavelength-dependent penetration.

2 Differentiate the modalities

LLLT, IPL, and multiwavelength PBM — mechanism, dosimetry, regulatory status, and appropriate indications.

3 Apply the AMD evidence

Use LIGHTSITE I–III and supporting RCTs to select candidates, counsel on expected outcomes, and implement the treatment protocol.

4 Evaluate safety & limits

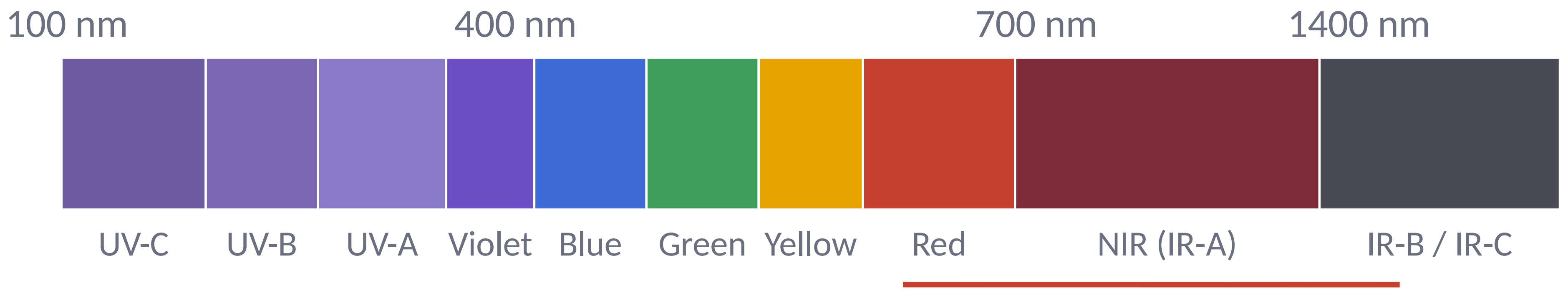
Safety profile, contraindications, Cochrane and AAO assessments, phototoxicity reports, and gaps in standardization.

AGENDA

Roadmap: Four Parts, 120 Minutes

I	Physics & Biology of Therapeutic Light	25 min
II	History of Light in Medicine	20 min
III	Anterior Segment: Dry Eye & MGD	35 min
IV	Posterior Segment: PBM for Dry AMD	40 min

The Electromagnetic Spectrum



Photobiomodulation band: ~600–1100 nm (red + near-infrared)

- Visible window: 400–700 nm; the "optical window" of useful tissue penetration spans roughly 600–1200 nm.
- Infrared subdivides into IR-A (760–1400 nm), IR-B, and IR-C — only IR-A is therapeutically relevant here.
- Every therapy in this lecture — IPL, LLLT, multiwavelength PBM — lives on this one axis. Where a device sits determines what it can reach and what it can do.

Photon Energy and the First Law of Photobiology

First law of photobiology: a photon must be absorbed by a molecule in the tissue to produce any biologic effect.

$$E = hc / \lambda$$

Planck relation: photon energy is inversely proportional to wavelength

- Shorter wavelength → higher photon energy → greater phototoxic potential (UV at the extreme).
- Longer wavelength → lower photon energy → deeper tissue penetration (near-infrared at the extreme).
- Therapeutic light design is the art of trading energy against depth to reach the intended chromophore safely.

KEY POINT No absorption, no effect — every claim about a light therapy must start by naming the absorbing molecule.

Hamblin MR. J Neurosci Res. 2018;96(4):731-743.

The Vocabulary of Dosimetry

Parameter	Units	What it determines
Wavelength	nm	Which chromophore absorbs; how deep the light travels
Irradiance (power density)	mW/cm^2	Rate of energy delivery
Fluence (energy density)	J/cm^2	Total dose delivered
Pulse structure / duty cycle	—	Peak vs. average power; thermal relaxation between pulses
Total irradiation time	s / min	Cumulative exposure; separates PBM from photothermal modes
Beam properties	—	Coherent (laser) vs. non-coherent (LED); collimated vs. divergent

KEY POINT Effective therapy is parameter-dependent — fluence, duration, and output power — not merely wavelength-dependent.

Maghfour J, et al. J Am Acad Dermatol. 2024;91(5):793-802.

Why "Red Light" Is Not One Therapy

Same wavelength, different irradiance

A 660 nm panel at 5 mW/cm^2 and a 660 nm laser at 500 mW/cm^2 are different interventions.

Same fluence, different delivery

10 J/cm^2 continuous vs. pulsed at low duty cycle produce different tissue responses.

Same device, different protocol

Session count, spacing, and total irradiation time change outcomes independently of the source.

Central teaching point: never compare devices on wavelength alone. Parameter variation is a recognized source of uncertainty in therapeutic efficacy and a barrier to standardization of treatment protocols.

Shi G, et al. J Photochem Photobiol B. 2026;282:113529.

Four Modes of Light–Tissue Interaction

Photochemical

Photon drives a chemical reaction

PDT · bilirubin photoisomerization · vitamin D synthesis

Photothermal

Absorbed energy becomes heat

Conventional retinal laser · micropulse · IPL lid heating

Photomechanical

Nanosecond pulses create mechanical disruption

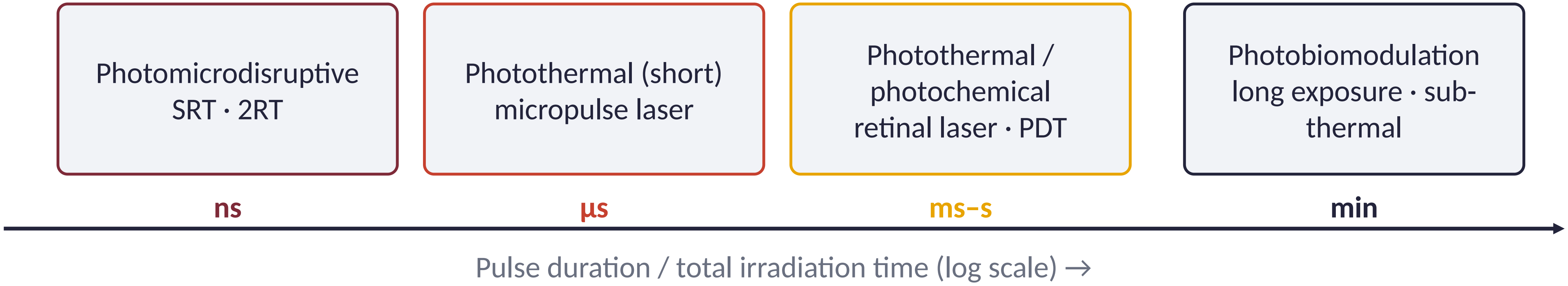
YAG capsulotomy · selective retina therapy (SRT) · 2RT

Photobiomodulation

Sub-thermal metabolic signaling

LLLT · multiwavelength retinal PBM — the subject of this course

The RELITE Nomenclature Framework

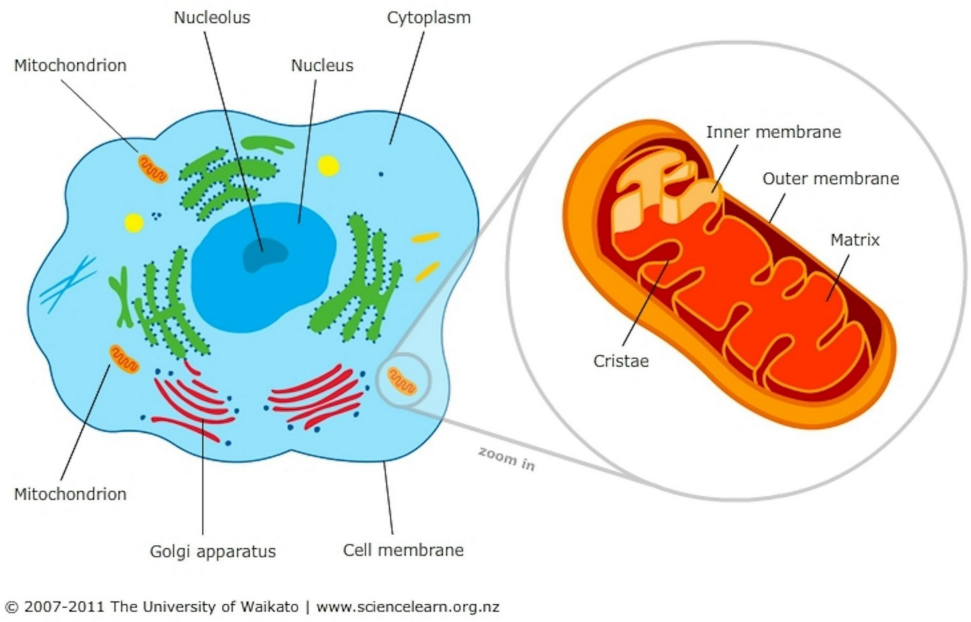


- Categorizes regenerative retinal laser and light therapies by pulse duration and total irradiation time.
- Explicitly separates PBM from photothermal and photomicrodisruptive modalities — a trial-reporting standard the field currently lacks.

von der Burchard C, et al. Lasers Surg Med. 2024;56(8):693-708.

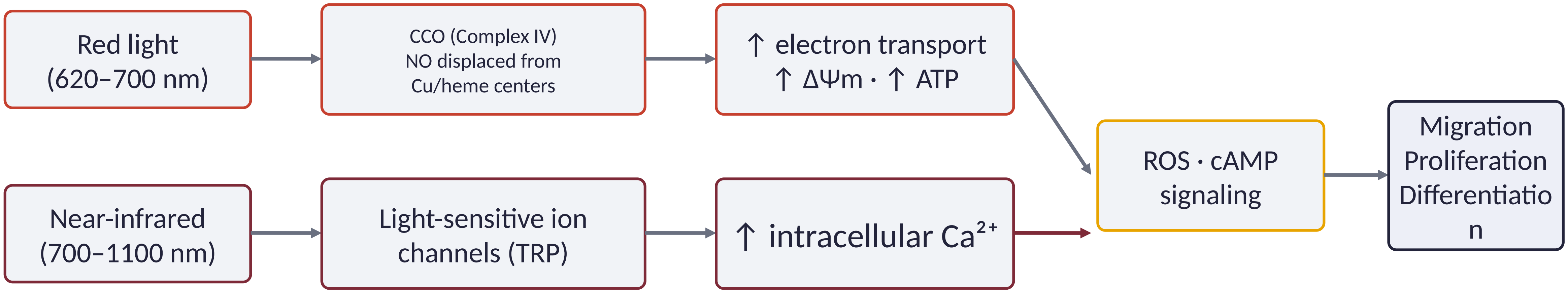
Cytochrome c Oxidase: The Primary Chromophore

- Complex IV of the mitochondrial electron transport chain — the terminal enzyme that hands electrons to oxygen.
- Contains heme a / a_3 and Cu_a / Cu_B redox centers — these metal centers are the light absorbers.
- Absorption peaks in the red and blue regions, extending into the near-infrared up to approximately 900 nm.
- Highly expressed in metabolically demanding tissue — photoreceptors and RPE are among the most mitochondria-dense cells in the body.
- The action spectrum for CCO activity and ATP content parallels CCO's NIR absorption spectrum, with activity increased at 660 and 850 nm.



The chromophore's home: Complex IV sits on the inner mitochondrial membrane.

The Nitric Oxide Photodissociation Hypothesis



- Nitric oxide competes with oxygen at CCO's active sites; photodissociation of NO restores oxygen binding and respiration.
- The red-light (CCO) and near-infrared (ion channel) pathways converge through ROS and cAMP onto gene-level effects.
- This is a hypothesis with strong but incomplete support — mechanism uncertainty is one reason PBM acceptance lagged for decades.

Secondary Chromophores and Ion Channels

Photoacceptor	Activating wavelengths	Downstream signal
TRP-superfamily channels (incl. TRPV1)	Green, red, near-infrared	Cation influx — calcium entry into the cytosol
Opsins (non-visual)	Blue–green	G-protein signaling cascades
Flavins / flavoproteins	Blue	Redox signaling, ROS generation
Cytochrome c oxidase (primary)	Red, near-infrared (to ~900 nm)	ATP, $\Delta\Psi m$, NO release

KEY POINT Multiple chromophores with different absorption spectra are the biologic rationale for multiwavelength devices.

Hamblin MR. J Neurosci Res. 2018;96(4):731-743.

Downstream Signaling: From Photon to Gene Expression

Second messengers

- Reactive oxygen species (signaling-level)
- Cyclic AMP
- Nitric oxide
- Calcium

→

Transcription pathways

- PI3K / Akt
- MAPK
- NF-κB modulation
- Transcription factor activation (e.g., via redox state)

→

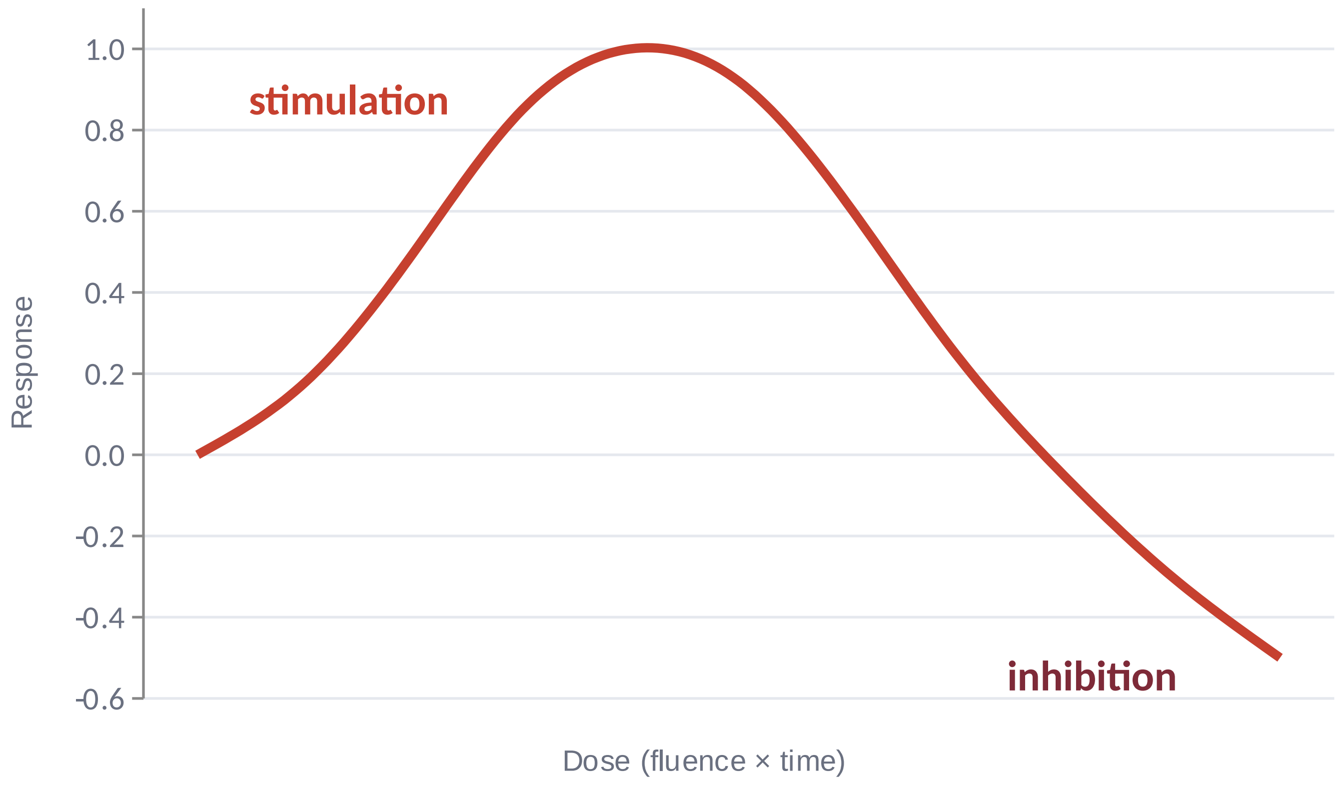
Gene programs ↑

- Protein synthesis
- Cell migration & proliferation
- Anti-inflammatory signaling
- Anti-apoptotic proteins
- Antioxidant enzymes

KEY POINT Stem and progenitor cells appear particularly susceptible to photobiomodulation — relevant to regenerative claims.

de Freitas LF, Hamblin MR. 2016 · Shi G, et al. 2026.

The Biphasic Dose Response (Arndt–Schulz Curve)



- PBM exhibits wavelength- and dose-dependent bidirectional regulation.
- Under-dosing → no measurable effect.
- Over-dosing → response flattens, then becomes inhibitory.

“More” is not “better” — the most practical single fact in this hour.

The Espresso Model of Dosimetry

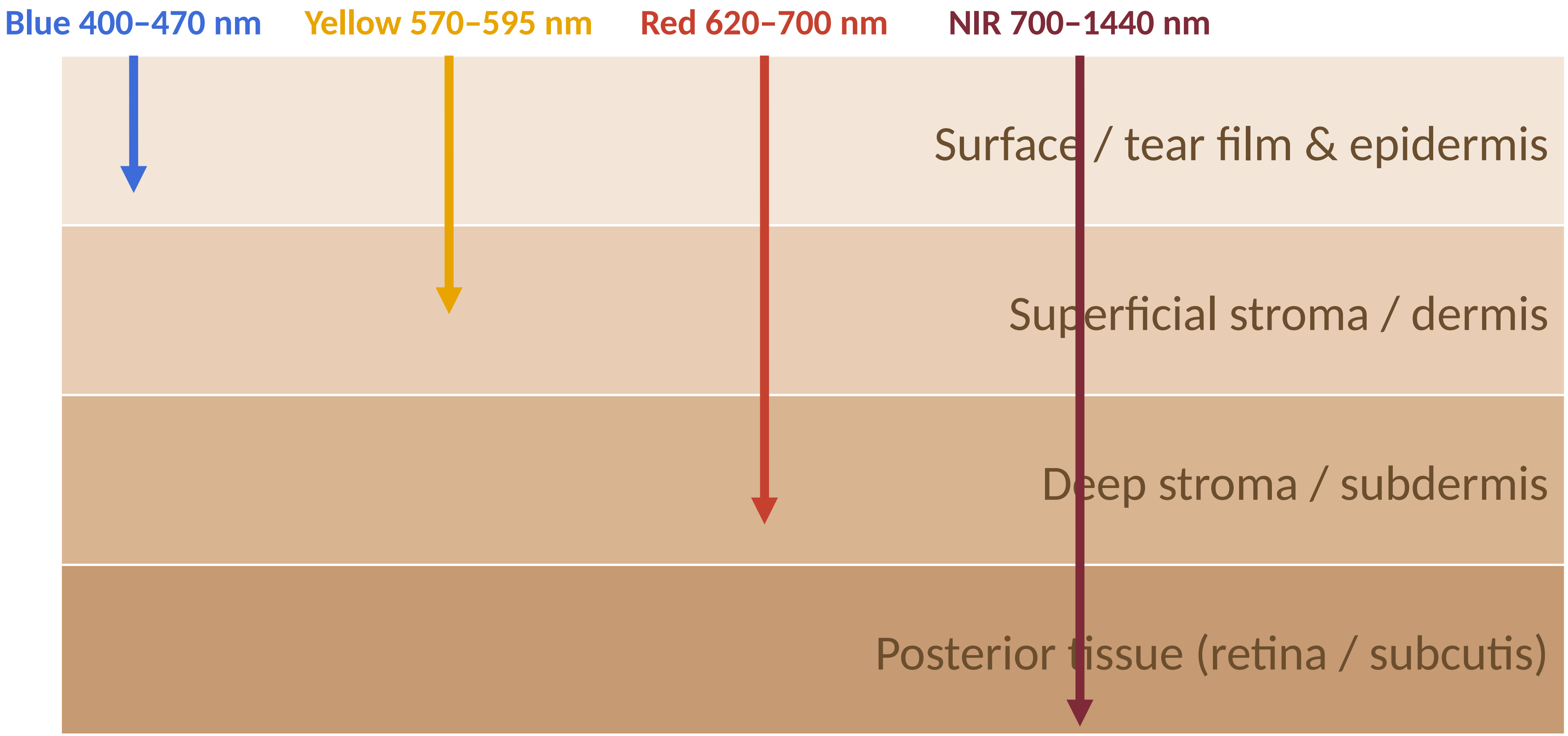
The roast you choose	→	**Wavelength (nm)** — selects the chromophore — what absorbs at all
How strong you brew	→	**Irradiance (mW/cm²)** — power density at the tissue
How long you drink	→	**Exposure time (s)** — duration per session
Total shots consumed	→	**Fluence (J/cm²)** — irradiance × time — the delivered dose
Sipping vs chugging	→	**Pulse structure** — same dose, different delivery, different biology
1 shot sharpens · 10 shots shut you down	→	**Biphasic dose response** — the Arndt–Schulz curve from the last slide

Same beverage, very different afternoon. Nobody orders “a coffee” at a specialty cafe — stop ordering “red light” from a device catalog. Parameters predict outcomes.

Analogy slide — dosimetry definitions per Zein R, et al. J Biomed Opt. 2018;23:120901.

Penetration Depth by Wavelength

- Red 620–700 nm and NIR 700–1440 nm are the therapeutic PBM bands.
- NIR reaches deepest — the choice for posterior segment targets.



Maghfour J, et al. J Am Acad Dermatol. 2024;91(5):793-802.

Part I Summary: Three Rules of Therapeutic Light

1. **Wavelength selects the chromophore**

   Which molecule absorbs — and therefore which tissue and which biology you engage.

2. **Dose determines direction**

   The biphasic curve: too little does nothing, too much inhibits.

3. **Parameters determine reproducibility**

   Irradiance, fluence, pulse structure, and schedule — the difference between a therapy and an anecdote.

PBM's promise as an adjunct: non-invasive, minimal tissue damage, favorable safety, low cost.

Shi G, et al. J Photochem Photobiol B. 2026;282:113529.

Ancient Heliotherapy: Five Millennia of Sun as Medicine

~3000 BCE — Egyptian records link sun exposure and skin disease — the earliest known association, five millennia old.

~1500 BCE — Egyptian and Indian healers combine plant extracts or seeds with sunlight to treat “leucoderma” — psoralen-like photochemotherapy avant la lettre.

Antiquity — Greek and Roman solaria; heliotherapy as a formal element of care.

Plant extracts + sunlight, ~1500 BCE (AI-generated illustration)

Jarrett P, Scragg R. Photochem Photobiol Sci. 2017;16(3):283-290 · Hönigsmann H. Photochem Photobiol Sci. 2013;12(1):16-21.

The 19th-Century Scientific Turn

1877

Downes & Blunt demonstrate that light exposure inhibits fungal growth and kills anthrax bacilli in test tubes — photobiology becomes an experimental science.

Enabling technologies

- Characterization of ultraviolet radiation
- The electric generator
- The electric lightbulb

KEY POINT These discoveries moved medicine from waiting for the sun to engineering the source — heliotherapy became phototherapy.

Jarrett P, Scragg R. 2017 · Grzybowski A, et al. Clin Dermatol. 2016;34(5):532-537.

Niels Ryberg Finsen (1860–1904): Founder of Modern Phototherapy

- Applied an electric carbon arc torch with quartz filters to treat lupus vulgaris — cutaneous Mycobacterium tuberculosis.
- Treated more than 800 patients at the Finsen Institute in Copenhagen.
- Awarded the 1903 Nobel Prize in Physiology or Medicine — the origin point of medical phototherapy as a discipline.
- Note the template he set: engineered source, filtered spectrum, defined target disease — the same anatomy as every modern device study.

Multi-arm carbon-arc phototherapy, early 1900s (AI-generated recreation)

Grzybowski A, et al. 2016 · Jarrett P, Scragg R. 2017.

Sanatoria, Rickets, and the Road to Vitamin D

1921

Sunlight published as the cure for rickets.

1925

Hess & Weinstock: UV-irradiated food prevents rickets in rats — the path to vitamin D.

1900s–1950s

European and North American sanatoria deploy heliotherapy for tuberculosis; UV therapy and vitamin D remain in use until antibiotics supersede them.

Jarrett P, Scragg R. Photochem Photobiol Sci. 2017;16(3):283-290.

Dermatologic Phototherapy Matures

- **1923** Goeckerman selects UVB with coal tar for psoriasis.
- **1932** AMA review lists 34 skin conditions for which UV radiation might be useful.
- **1947** Methoxypsoralen isolated.
- **1974** PUVA photochemotherapy — photodermatology expands rapidly.
- **1980s** Narrow-band UVB emerges from action-spectrum work in psoriasis.

Grzybowski A, et al. 2016 · Hönigsmann H. 2013 · Bouceiro Mendes R, et al. Photodermatol Photoimmunol Photomed. 2022;38(3):215-223 · Jarrett & Scragg 2017.

Phototherapy Expands Beyond Dermatology

Neonatology

Blue-light phototherapy for hyperbilirubinemia — next two slides.

Psychiatry

Bright-light therapy for seasonal affective disorder.

Ophthalmology

From retinal photocoagulation to photobiomodulation — the rest of this course.

Grzybowski A, et al. Clin Dermatol. 2016;34(5):532-537.

Neonatal Jaundice: From Nursing Observation to Standard of Care

1950s

Rochford Hospital, England: Sister J. Ward observes jaundice fading on the sun-exposed skin of premature infants.

→

1958

Cremer, Perryman & Richards publish the influence of light on infant hyperbilirubinaemia in The Lancet.

→

1968

Lucey's randomized controlled trial establishes efficacy — phototherapy becomes standard of care.

Blue LED phototherapy with eye shields (AI-generated illustration)

KEY POINT Serendipity → case report → randomized trial: the same evidentiary arc photobiomodulation is traversing today.

Cremer RJ, et al. Lancet. 1958;1(7030):1094-1097 · Lucey J, et al. Pediatrics. 1968;41(6):1047-1054.

Blue Light as a Dosed Drug

- Sources evolved: fluorescent tubes → halogen spotlights → fiberoptic pads → narrow-band blue LEDs matched to the bilirubin photoisomerization peak (~458 nm).
- The prescription is a dose: irradiance, lamp distance, and exposed surface area — titrated like a drug.
- Devices should emit no UV and no infrared — spectral purity is a safety parameter, not a refinement.

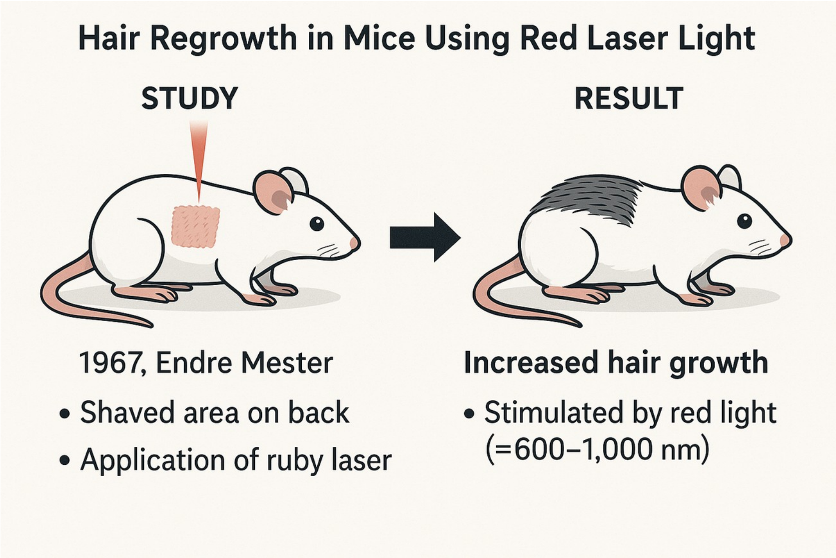
The “dose” of phototherapy

- Spectral match to the chromophore
- Irradiance at the skin
- Distance from source
- Exposed surface area
- Duration of exposure

An exact template for how we will evaluate ocular devices.

Mester and the Accidental Discovery of Biostimulation

- Budapest, late 1960s: Endre Mester applies a low-power ruby laser to shaved mice expecting to test carcinogenicity.
- Instead: accelerated hair regrowth and faster wound healing — laser "biostimulation" is born, later renamed low-level laser therapy (LLLT).
- The finding was real but the field stalled: photobiomodulation has been known for almost 50 years yet did not gain widespread acceptance, largely because of persistent uncertainty about its mechanisms.
- Lesson for the audience: a therapy without a mechanism narrative struggles for legitimacy regardless of its data — which is why Part I of this course exists.



1967: shaved mice, a ruby laser — and unexpectedly faster hair regrowth.

de Freitas LF, Hamblin MR. IEEE J Sel Top Quantum Electron. 2016;22(3):7000417.

NASA LEDs and the Terminology Shift

- NASA develops LED arrays for plant growth and wound-healing experiments in microgravity.
- Those device families (e.g., WARP-10, GentleWaves) are later repurposed for early ocular pilot studies in AMD — the TORPA series in Part IV.
- Coherence proves unnecessary: inexpensive, safe LED sources reproduce laser biostimulation effects.

Red LED plant-growth arrays (AI-generated)

Naming the field

Low-level laser therapy
laser-era term
↓
Low-level light therapy
admits LEDs
↓
Photobiomodulation (PBM)
current standard — mechanism-based, source-agnostic

Dermatology as the Proving Ground for LED Therapy

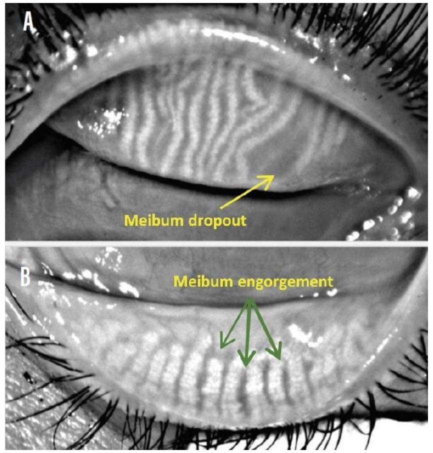
Band	Wavelengths	Dermatologic effect
Blue	400–470 nm	Porphyrin-mediated antibacterial effect (C. acnes); barrier repair
Yellow	570–595 nm	Melanogenesis suppression; melasma, photoaging
Red	620–700 nm	Collagen synthesis, wound healing, hair growth
Near-infrared	700–1440 nm	Deep repair; pigmentary disorders, accelerated wound healing

- PBM is generally well-tolerated and safe — erythema is the most common cutaneous adverse effect and is self-limiting.
- Combination-wavelength protocols outperforming single wavelengths set the conceptual precedent for multiwavelength ocular PBM.

Maghfour J, et al. J Am Acad Dermatol. 2024;91(5):793-802.

Clinical Framing: Evaporative Dry Eye and MGD

- Evaporative dry eye with meibomian gland dysfunction is the dominant subtype in clinic populations.
- Chronic, progressive, and structurally consequential — gland dropout is not recoverable.
- Device-based light therapy targets the drivers, not just the symptoms.



Meibography: dropout & engorgement (our clinic)

Therapeutic targets

- Terminal duct obstruction
- Elevated meibum viscosity
- Lid margin inflammation & telangiectasia
- Demodex colonization
- Ocular rosacea

Where Light Therapy Sits: TFOS DEWS III Staged Management

Step 1 · Tear film replenishment & conservation

Lubricants, environmental modification, lid measures

Step 2 · MGD-directed therapy

Warm compresses · device lid warming · IPL · LLLT

Step 3 · Lid hygiene & anti-inflammatory therapy

Topical/systemic anti-inflammatories, biologics

Step 4 · Advanced options

Surgical and specialty interventions

IPL and LLLT sit at Step 2 — after replenishment, alongside gland-directed physical therapy.

Jones L, Craig JP, Markoulli M, et al. TFOS DEWS III Management and Therapy Report. Am J Ophthalmol. 2025.

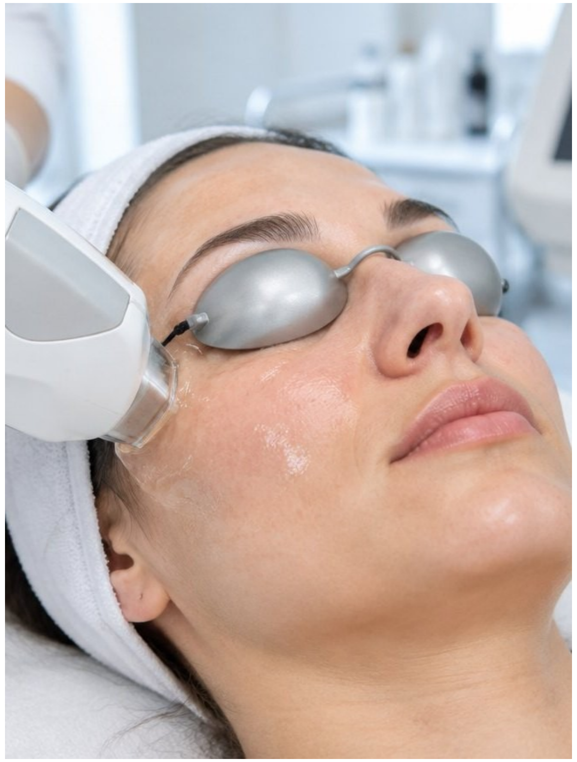
IPL vs. LLLT: Establish the Distinction Early

	Intense Pulsed Light (IPL)	Low-Level Light Therapy (LLLT)
Source	Xenon flashlamp, broadband 500–1200 nm, filtered	LED array, narrow-band (typically 590–633 nm)
Physics	High-energy pulse trains — photothermal / vascular	Low irradiance, continuous — photobiomodulation
Where applied	Periocular skin, eyes shielded	Over closed eyelids
Primary target	Telangiectasia, inflammation, meibum viscosity, Demodex	Cellular metabolism of lid and gland tissue
In practice	*Different physics, different targets — frequently combined in a single session*	

D'Souza S, et al. *Cornea*. 2022;41(9):1080-1087.

IPL Physics

- **Source** — Xenon flashlamp — broadband, non-coherent, 500–1200 nm
- **Filtering** — Cut-off / notch filters shape the spectrum (e.g., 590 nm "acne" filter blocks shorter wavelengths)
- **Delivery** — Pulse trains with controlled pulse width and intervals
- **Coupling** — Chilled optical gel couples the handpiece and protects the epidermis
- **Safety** — Opaque eye shields are mandatory — always, every pass



Opaque shields, coupling gel, periocular passes (AI-generated illustration)

IPL: Proposed Mechanisms in MGD

Vascular

Closure of abnormal telangiectatic lid margin vessels — removing a source of inflammatory mediators

Anti-inflammatory

Reduction of inflammatory cytokines measurable in tears

Thermal

Heating liquefies viscous, inspissated meibum, easing expression

Antiparasitic

Reduction of Demodex burden on the lids

AAO Ophthalmic Technology Assessment: IPL for MGD

12

studies assessed:
4 level II · 8 level III

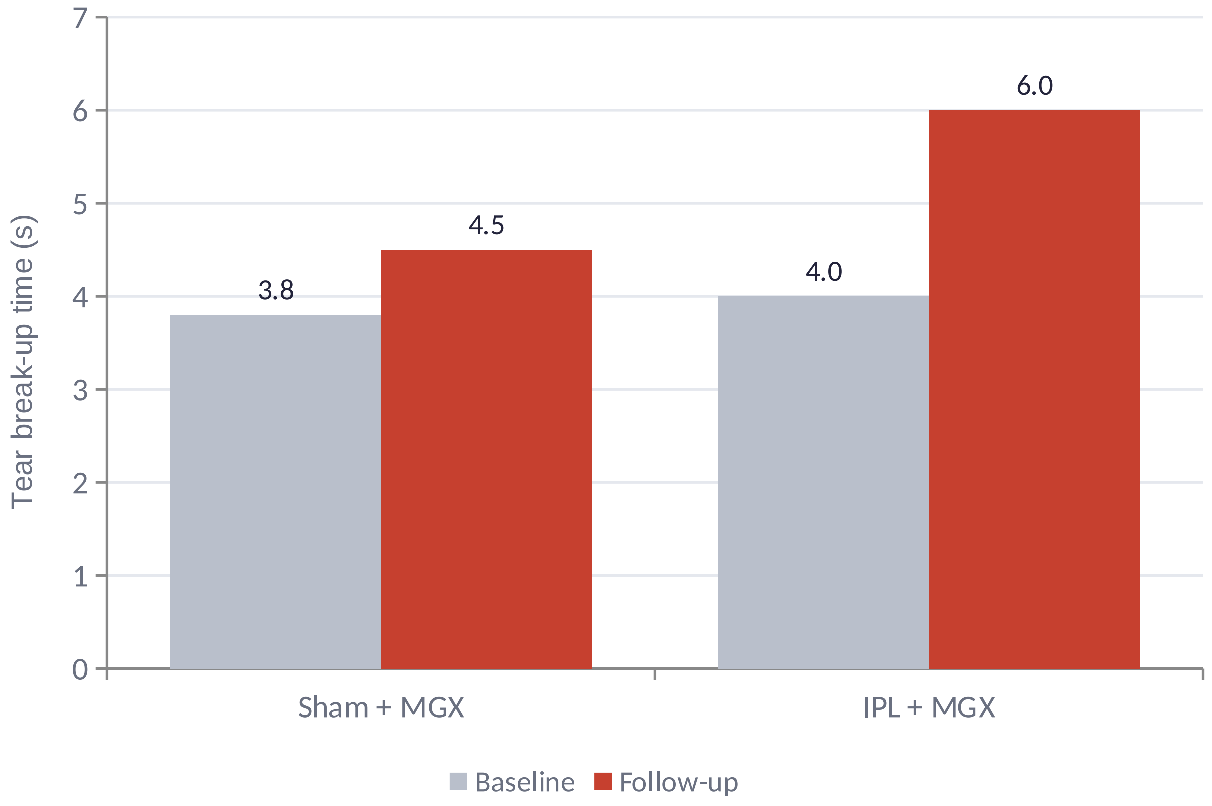
All 12 documented improvement in clinically meaningful metrics:

tear break-up time · corneal staining · eyelid margin measurements · meibum quality · gland expressibility · OSDI · SPEED

- Side effects were relatively uncommon — discomfort, cutaneous erythema, blistering, eyelash loss, floaters — and uniformly self-limited.
- Five of the twelve studies had potential conflicts of interest and design limitations affecting interpretation — keep that weight in mind as we read the trial data next.

Wladis EJ, Aakalu VK, Foster JA, et al. Ophthalmology. 2020;127(9):1227-1233.

Randomized Evidence: IPL + MGX vs. Sham + MGX



- Design: 1:1 randomization, 4 sessions at 2-week intervals; patients and examiners blinded.
- Primary outcome (TBUT): IPL+MGX 4.0 → 6.0 s vs. sham+MGX 3.8 → 4.5 s — between-arm difference significant (P < .01).
- No serious adverse events in either arm.

Toyos R, Desai NR, Toyos M, Dell SJ. PLoS One. 2022;17(6):e0270268.

Same Trial: Secondary Outcomes — and the Honest Caveats

Favored IPL + MGX

- Meibomian gland score ($P < .001$)
- Eye Dryness Score ($P < .01$)
- Expressible gland counts, upper and lower lids ($P < .0001$)
- Predominant meibum quality, both lids ($P < .0001$)
- Less pain during expression ($P < .0001$)

The honest caveats

- OSDI improved in both arms with no between-arm difference ($P = .9984$) — expression alone relieves symptoms
- Daily artificial tear use: no between-arm difference ($P = .8216$)
- Meibography (gland structure): no significant change in either arm
- Sponsor-funded; authors consult for the manufacturer

Toyos R, et al. PLoS One. 2022;17(6):e0270268.

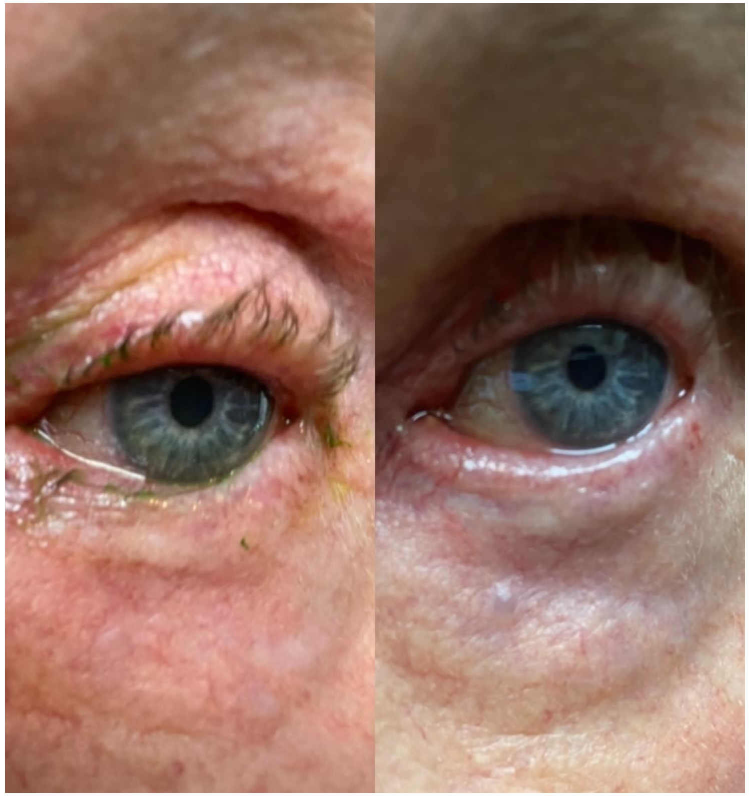
Arita: Level II Data with 32-Week Follow-up

+21.3 nm	+4.5 s	−9.2	−1.9 / 6
lipid layer thickness (max mean increase)	tear break-up time	SPEED symptom score at 32 weeks	eyelid margin score

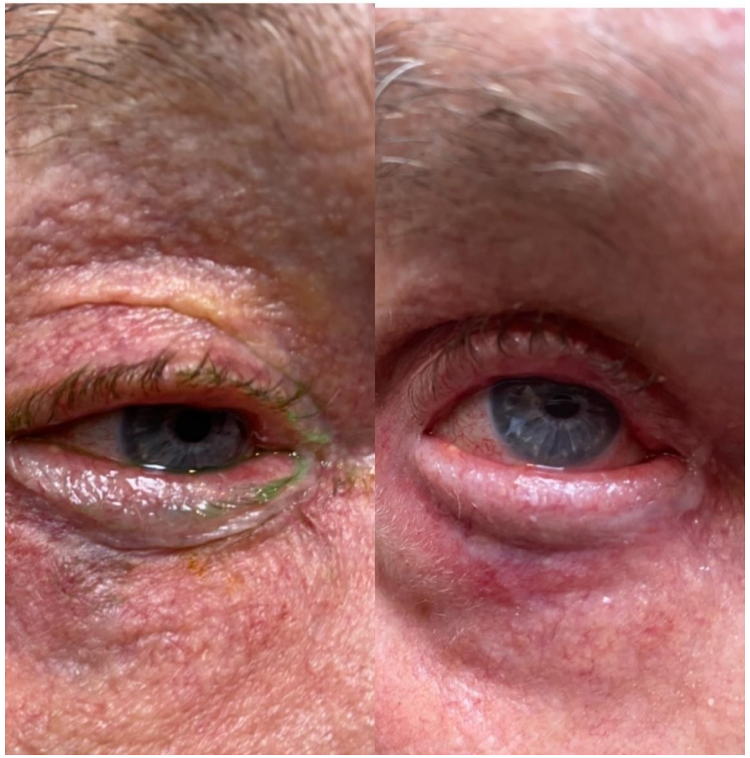
- Design: 90 eyes of 45 patients; M22 device at 14–16 J/cm²; 8 sessions at 3-week intervals; outcomes through 32 weeks.
- Also improved: meibum grade (−0.3) and corneal staining (−1.0) vs. expression alone.
- Caveats: three patients withdrew because of IPL-associated pain; the first author consulted for the device manufacturer.

Arita R, et al. — summarized in Wladis EJ, et al. Ophthalmology. 2020;127(9):1227-1233.

What Improvement Looks Like: From Our Chairs



Lid margin — before (L) and after (R) IPL series



Lid margin & lashes — before (L) and after (R)

Periocular erythema — IPL series

Honest frame: single cases, not trials — the RCTs you just saw are why we expect this; these are why patients say yes.

Patient photographs: Hazleton Eye Specialists / The Dry Eye Clinic of NEPA — written photography consent on file for all images.

IPL in Practice: A Typical Protocol

1. **Screen** — Fitzpatrick type, medications, lesions, devices
2. **Shield** — Opaque eye protection — mandatory, every pass
3. **Treat** — Fluence titrated to skin type; gel coupling; tragus-to-tragus passes
4. **Express** — Post-treatment meibomian gland expression
5. **Repeat** — 3–4 sessions at 2–4 week intervals; reassess

KEY POINT Expression after IPL is part of the therapy, not an optional add-on — the trial evidence is for the combination.

IPL Safety and Contraindications

Screen before treating

- Fitzpatrick V–VI: heightened caution, adjusted fluence
- Recent tanning or sun exposure
- Photosensitizing medications: isotretinoin, doxycycline, amiodarone, St. John's wort — but hold that thought (next slide)
- Active herpetic disease · pregnancy
- Melanocytic or suspicious lesions in the field
- Gold implants · pacemakers/ICDs per manufacturer labeling

What the assessment found

- Reported side effects are uncommon and self-limited.
- Typical events: transient discomfort, cutaneous erythema; rarely blistering, eyelash loss, floaters.
- No pattern of serious or permanent harm across the 12 assessed studies.

Fitzpatrick typing guides candidacy & settings

The Doxycycline Paradox

What the labels say

- Photosensitizing medications listed as an IPL precaution
- Tetracyclines (doxycycline), isotretinoin, St. John's wort, amiodarone
- Standard advice: hold the drug or defer the light

What the physics says

- Drug phototoxicity action spectra live in the UVA: 320–400 nm
- Filtered IPL emits ≈ 500–1200 nm — the activating wavelengths never leave the handpiece
- Part I rule, again: no absorption, no effect

What the evidence says

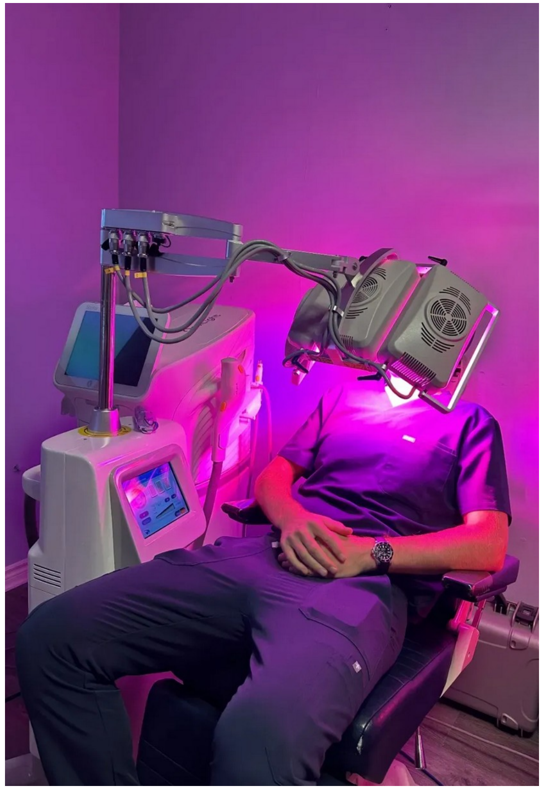
- Kerstein 2014 systematic review: zero published adverse cases of laser/IPL + photosensitizers
- Schilling 2019: 36 rosacea patients on doxycycline through IPL/PDL — no photosensitivity events
- Sorg 2007: >500 nm IPL → no thymine dimers (no UV-type DNA damage)

In our clinic: doxycycline and IPL often run together on purpose — synergistic MGD/rosacea control. Know the labeling, document your reasoning, and treat isotretinoin as its own conversation.

Kerstein RL, et al. Lasers Med Sci. 2014;29(4):1449-52 · Schilling LM, et al. Dermatol Surg. 2019;45(11):1401-05 · Sorg O, et al. Arch Dermatol. 2007;143(3):363-66.

LLLT: Parameters and Delivery

- **Wavelength** — 590–633 nm LED arrays (device-dependent; some add NIR)
- **Application** — Mask or panel over closed eyelids
- **Session** — Typically ~15 minutes
- **Sensation** — Gentle warmth — often paired with lid warming
- **Course** — Multiple sessions over weeks; maintenance as needed



633 nm LED mask in use — closed lids, low irradiance.

Randomized, Observer-Masked LLLT Trial

Significant vs. placebo

- Fluorescein corneal staining — the primary endpoint
- Lissamine green conjunctival staining
- Schirmer testing
- Upper meibography scores

Improved, not significant

- Tear break-up time
- Lid debris · lid swelling · telangiectasia
- Meibum secretion and expressibility

Design: 6 sessions over 3 weeks, observer-masked, placebo-controlled. No serious adverse events.

Park Y, Kim H, Kim S, Cho KJ. Sci Rep. 2022;12:3575.

Prospective 633 nm LLLT: What Improves — and What Doesn't

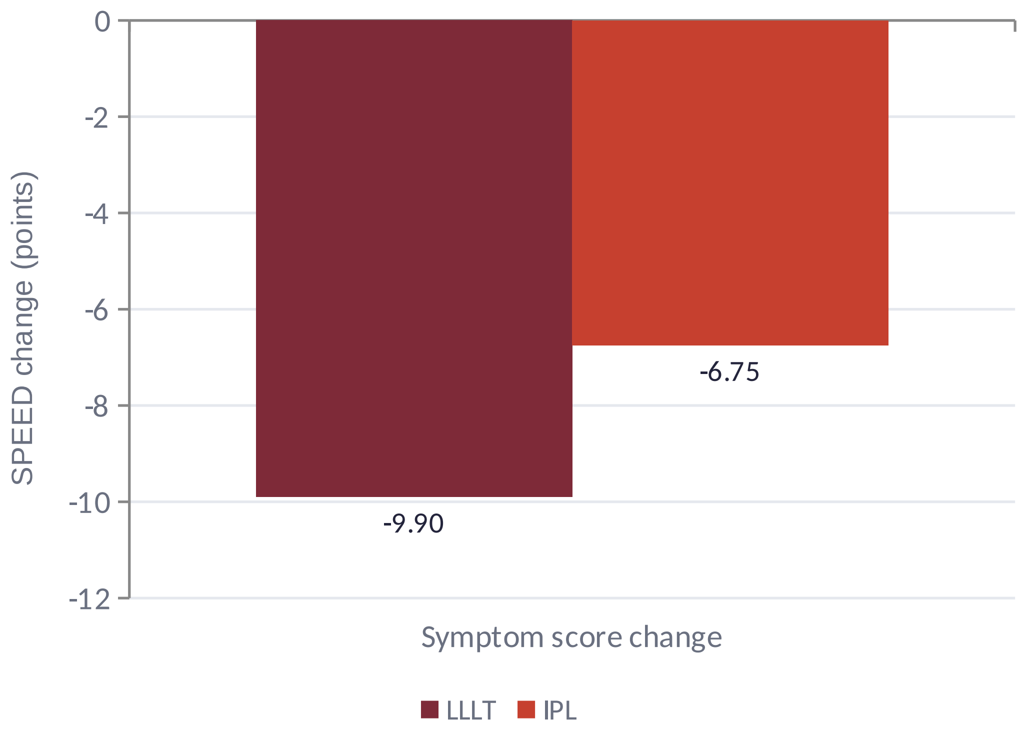
+12.9 nm	**+0.06 mm**	**−10.2**	**+7.0 °C**
lipid layer thickness	tear meniscus height	OSDI symptom score	eyelid temperature (upper & lower)

- Also significant: first and average non-invasive break-up time and meibum quality (15 min × 3 visits).

Unchanged: corneal fluorescein staining and meibomian gland dropout. LLLT relieves symptoms and improves tear film function — it does not regenerate lost glands. Set expectations accordingly.

Antwi A, Schill AW, Redfern R, Ritchey ER. Ophthalmic Physiol Opt. 2024;44(7):1464-1471.

Head-to-Head: LLLT vs. IPL



- Symptom score: greater improvement with LLLT (−9.9 ± 3.2 vs. −6.75 ± 4.5; P = 0.014).
- Tear meniscus height: increased with LLLT, not IPL (0.06 ± 0.10 mm vs. −0.01 ± 0.014 mm; P = 0.040).
- No significant change in either group: non-invasive break-up time, redness score, meiboscore, gland loss.
- No adverse events in either arm — both modalities tolerated well over 4 weekly sessions.

Giannaccare G, Pellegrini M, Carnovale Scalzo G, et al. Cornea. 2023;42(2):141-144.

Combined IPL + LLLT: Clinical Outcomes in Recalcitrant Disease

95.6%

of eyes: OSDI significantly reduced

72.3%

of eyes: tear break-up time increased

80.8%

of eyes: gland expressibility improved

- Population: 94 eyes with recalcitrant evaporative dry eye disease and MGD — a difficult, pre-treated group.
- Intervention: a single combined IPL + LLLT session (Eye-light device).
- All three outcomes significant at 3 months ($P < .05$) and sustained at 6 months.

D'Souza S, Padmanabhan Nair A, Iyappan G, et al. Cornea. 2022;41(9):1080-1087.

Combined IPL + LLLT: Molecular Correlates

↓ **IL-1β**
pro-inflammatory cytokine

↓ **IL-17F**
Th17-axis cytokine

↓ **MMP-9**
matrix metalloproteinase

↓ **MMP-9 / TIMP-1**
protease-inhibitor balance

↓ **B-cell proportion**
ocular surface immune profile

KEY POINT All reductions statistically significant ($P < .05$). The tear-film proteome corroborates the clinical response — this is not placebo arithmetic.

D'Souza S, et al. Cornea. 2022;41(9):1080-1087.

Anterior Segment Cases (Interactive — 5 min)

Case 1

- 48-year-old with rosacea and telangiectatic lid margins
- Oxford grade 2 corneal staining

Discussion: build an IPL-anchored plan — filter choice, fluence for skin type, session cadence, expression.

Case 2

- 62-year-old with advanced gland dropout on meibography
- Symptomatic despite lid hygiene and lubricants

Discussion: symptom relief is achievable without structural reversal — frame expectations before the first session, not after the last.

Toyos 2022 · Wladis 2020 · Antwi 2024 · Giannaccare 2023.

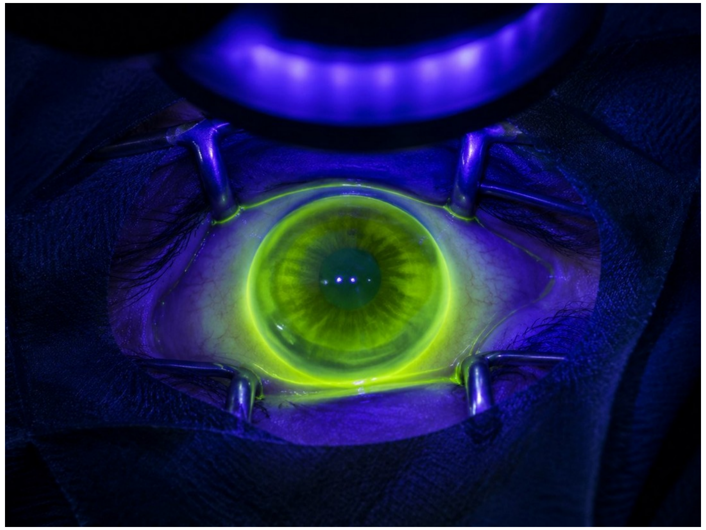
Crosslinking: The Photochemical Quadrant, Realized

The mechanism — a designed chromophore

- Riboflavin 5′-phosphate (vitamin B2) saturates the stroma — an installed photosensitizer
- UVA at 365 nm excites riboflavin → singlet oxygen → covalent crosslinks between collagen fibrils
- Result: a measurably stiffer cornea — progression of ectasia halts
- Oxygen is a reagent: crosslinking consumes O_2 — the chemistry that shaped 2025's new protocol

Every Part I rule, on display

- Grotthuss–Draper: no absorption, no effect — here the absorber is supplied in a bottle, not borrowed from the mitochondria
- Dosimetry: Dresden protocol = 3 mW/cm² × 30 min = 5.4 J/cm²
- Accelerated protocols trade irradiance against time at matched fluence — reciprocity, with limits set by oxygen depletion
- Four-modes grid: this is the photochemical quadrant — PBM's neighbor, not its sibling



Riboflavin fluorescence under UVA (AI-generated illustration)

Contrast to remember: PBM borrows an endogenous chromophore to signal; CXL installs an exogenous one to build. Same physics discipline, opposite quadrant.

Wollensak G, et al. Am J Ophthalmol. 2003;135:620-627 · Photrexa/KXL Prescribing Information (FDA, 2016).

CXL Evidence: From Dresden to Epi-On (October 2025)

Epi-off: the established standard

- Dresden protocol (Wollensak 2003) → first US FDA approval April 2016 (Photrexa / KXL)
- Indication: progressive keratoconus and post-refractive corneal ectasia
- Halts progression; the alternative it prevents is corneal transplantation
- A generation of keratoconus patients has already been changed by a light therapy

Epi-on: approved October 20, 2025

- Epioxa HD 0.239% / Epioxa 0.177% — first FDA-approved epithelium-on CXL; ages 13+
- Oxygen-enriched: O_2n system + Boost Goggles feed the O_2-hungry photochemistry
- Two Phase 3 RCTs, 400+ patients — primary endpoint met (≥1.0 D Kmax difference vs sham, 12 mo)
- No epithelial debridement → less pain, faster recovery; commercial early 2026
- Caution: herpetic keratitis history (UV reactivation); aphakia/pseudophakia without UV-blocking IOL

Why it belongs in this lecture: CXL is the proof that a light-driven eye therapy can travel bench → FDA → standard of care. That is the road PBM is on.

Glaukos press release & Epioxa Prescribing Information, Oct 20, 2025 · Review of Optometry, Oct 2025 · Healio, Oct 2025.

The CXL Playbook: What 0402T Teaches Us About 0936T

2016

Approval → coding chaos

Billed on Category III 0402T + unclassified drug code — frequent denials and rejections

2019

Advocacy → J-code

ASCRS-led push wins dedicated J2787 for riboflavin — claims clean up

2026

Tenth year → covered

≈95% of payers cover epi-off — while 0402T is STILL a Category III code

The lessons for retinal PBM — and for your Tuesday-morning claims

- Category III ≠ non-covered: CXL reached ~95% payer coverage without ever earning a Category I code — documentation of progression + preauthorization discipline did the work
- History rhymes in real time: brand-new epi-on is being excluded as “experimental” by major payers today — the same wilderness 0936T is in right now

Bridge to Part IV: one light therapy already ran this whole course, from photochemistry to paid claims. Now: the retina.

ASCRS CXL Billing Guidelines · AAO CXL Coding Fact Sheet (2023) · Ophthalmology Management, 2026 (“tenth year” review).

The Unmet Need in Non-Neovascular AMD

Early / intermediate

AREDS2 supplementation · risk-factor modification · monitoring

THE GAP

No approved therapy modifies progression in early and intermediate disease

Established GA

Complement inhibition for geographic atrophy; anti-VEGF if exudative conversion

- Dry AMD remains a leading cause of irreversible central vision loss in older adults.
- Patients in the gap are told to take vitamins and wait — the population every optometrist manages, and the population the PBM trials enrolled.

Vemulakonda GA, Bailey ST, Kim SJ, et al. AAO Preferred Practice Pattern. Ophthalmology. 2025;132(4):P1-P74.

Pathophysiologic Rationale: Why PBM Might Work Here

RPE mitochondrial dysfunction	PBM's primary target is mitochondrial — CCO-mediated bioenergetic restoration
Oxidative stress	PBM upregulates antioxidant enzyme programs
Impaired outer-segment phagocytosis	ATP-dependent RPE housekeeping — energy supply is rate-limiting
Drusen accumulation	Downstream of RPE metabolic failure; the measurable anatomic burden
Chronic parainflammation	PBM's documented anti-inflammatory signaling

de Freitas LF, Hamblin MR. 2016 · Shi G, et al. 2026.

Retinal PBM Mechanism

- Cytochrome c oxidase upregulation — demonstrated at 670 nm in photoreceptors, with additional effects documented in RPE and Müller cells.
- Additional reported effects: reduced inflammation, modulated phagocytosis, VEGF downregulation, direct neuroprotection.
- The precise site and mechanism of action remain under active debate — including PBM's placement within the RELITE framework.

Cellular targets

Photoreceptors

highest mitochondrial density in the body

RPE

phagocytosis, transport, drusen biology

Müller cells

metabolic support, inflammation

Boyer D, et al. Retina. 2024;44(3):487-497 · de Freitas & Hamblin 2016 · Siqueira RC. Clin Ophthalmol. 2024;18:215-225.

Preclinical Foundations: Why Anyone Believed This

670 nm rescues CCO poisoning	Methanol-derived formate inhibits CCO; three brief 670 nm doses preserved rod/cone ERG and retinal structure in rats — toxin and therapy meet at one enzyme.
670 nm quiets complement	Reduced C3 deposition on Bruch's membrane and photoreceptors in $CFH^{-}/^{-}$ AMD-model mice — the same pathway approved GA drugs target.
NO is reduced in human AMD	eNOS and nNOS immunoreactivity fall in AMD eyes — the mechanistic seat for 590 nm nitric-oxide stimulation.
Multiwavelength: protective, non-toxic	Protected retinal layers in a $NaIO_3$ rat model; no RPE cytotoxicity in culture up to 18 J/cm^2.

All preclinical — animal models and cell culture. Presented as rationale, not as clinical evidence.

Eells JT, et al. Proc Natl Acad Sci USA. 2003;100:3439-3444 · Begum R, et al. PLoS One. 2013;8:e57828 · Bhutto IA, et al. Exp Eye Res. 2010;90:155-167 · Goo H, et al. Int J Mol Sci. 2023;24.

Why Multiwavelength?

590 nm

delivered open eye

stimulates nitric oxide synthesis and vasodilation — improved local oxygenation and nutrient delivery

660 nm

delivered closed lid

promotes O_2 binding at the Cu_B center — stimulates ATP; inhibits inflammation and cell death

850 nm

delivered open eye

drives electron transfer at the Cu_a center — stimulates ATP; deepest penetration to photoreceptors and RPE

KEY POINT Three wavelengths, two delivery routes, complementary chromophores and depths — the multiwavelength logic from dermatology, applied to the retina.

Wong-Riley MTT, et al. J Biol Chem. 2005;280:4761-4771 · Ball KA, et al. J Photochem Photobiol B. 2012;102:182-191 · Boyer D, et al. Retina. 2024.

Pilot Work: TORPA I and II

- Interventional case series using off-label NASA-lineage devices (WARP-10, GentleWaves).
- Protocol: 590, 670, 790 nm; pulsed 2.5 Hz; 0.1 J/cm^2 per treatment; three times weekly for six weeks.
- TORPA II at 3 months: mean BCVA +5.14 ETDRS letters ($P < .001$), contrast sensitivity gain, reduced drusen volume and central thickness — without new geographic atrophy.
- Effect declined after roughly 4 months — establishing the rationale for periodic re-treatment that every later trial adopted.

+5.14

ETDRS letters at 3 months (TORPA II)

Pilot-grade evidence: uncontrolled case series — hypothesis-generating, not practice-changing on its own.

Merry GF, et al. Acta Ophthalmol. 2017;95(4):e270-e277.

The Negative Evidence: LIGHTSITE I / II and Cochrane

LIGHTSITE I, LIGHTSITE II, and the 2021 Cochrane systematic review did not show a benefit of photobiomodulation for non-exudative AMD.

- Early trials were small, endpoints varied, and effects did not reach significance.
- The Cochrane conclusion (2021): evidence insufficient to demonstrate benefit.
- Everything you are about to see must be weighed against this starting point — not presented in isolation from it.

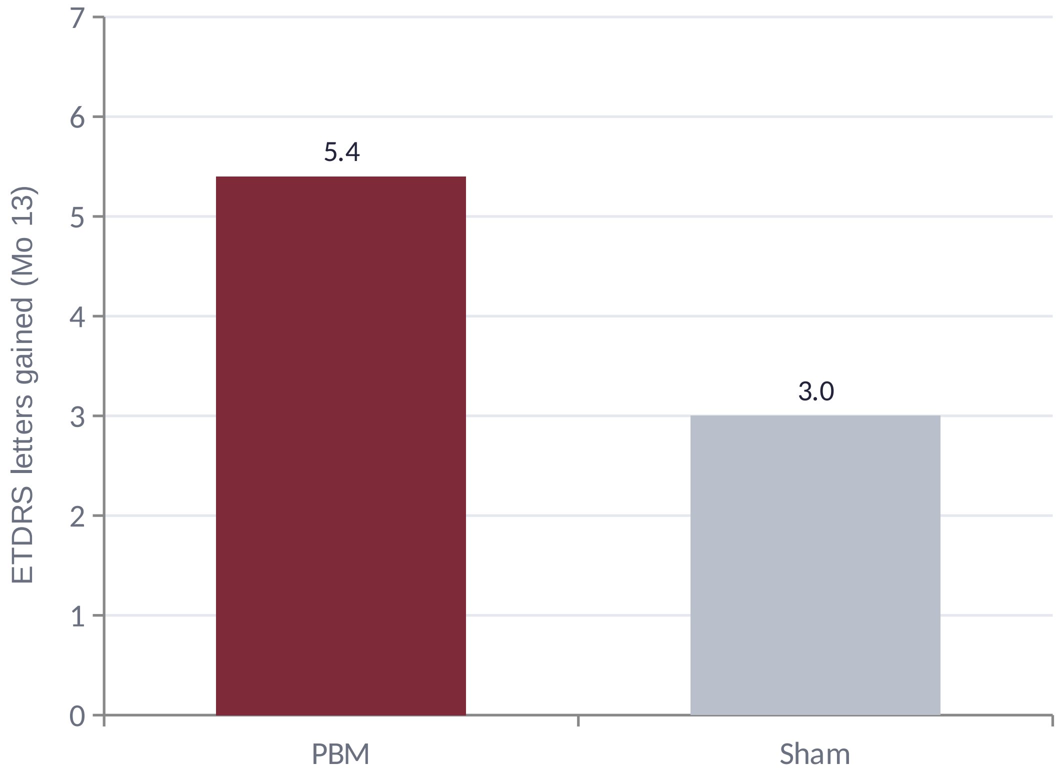
Henein C, Steel DH. Cochrane Database Syst Rev. 2021;5:CD013029 · Vemulakonda GA, et al. AAO PPP. Ophthalmology. 2025.

LIGHTSITE III: Design

Design	Double-masked · randomized · sham-controlled · parallel-group · multicenter · prospective
Population	100 subjects / 148 eyes with dry (non-neovascular) AMD
Intervention	Multiwavelength PBM: 590, 660, 850 nm — 2:1 randomization vs. sham
Sham	Not optically empty: 10×/100×-reduced 590 and 660 nm; 850 nm removed
Schedule	9 treatments over 3–5 weeks, repeated every 4 months, through 24 months

Each dot = a 9-session series delivered over 3–5 weeks

LIGHTSITE III: 13-Month BCVA — Primary Endpoint Met



- Primary BCVA endpoint met: between-group difference 2.4 letters (SE 1.15; P = 0.02).
- PBM arm: +5.4 letters (95% CI 3.5–7.3; P < .0001 within group). Sham arm: +3.0 letters.

Why did sham eyes gain 3 letters? Repeat ETDRS testing effects — and the sham was not optically empty (low-dose 590/660 nm). A conservative comparator that, if anything, understates the treatment effect.

Boyer D, et al. Retina. 2024;44(3):487-497.

LIGHTSITE III: 13-Month Anatomic Outcome

OR 9.4

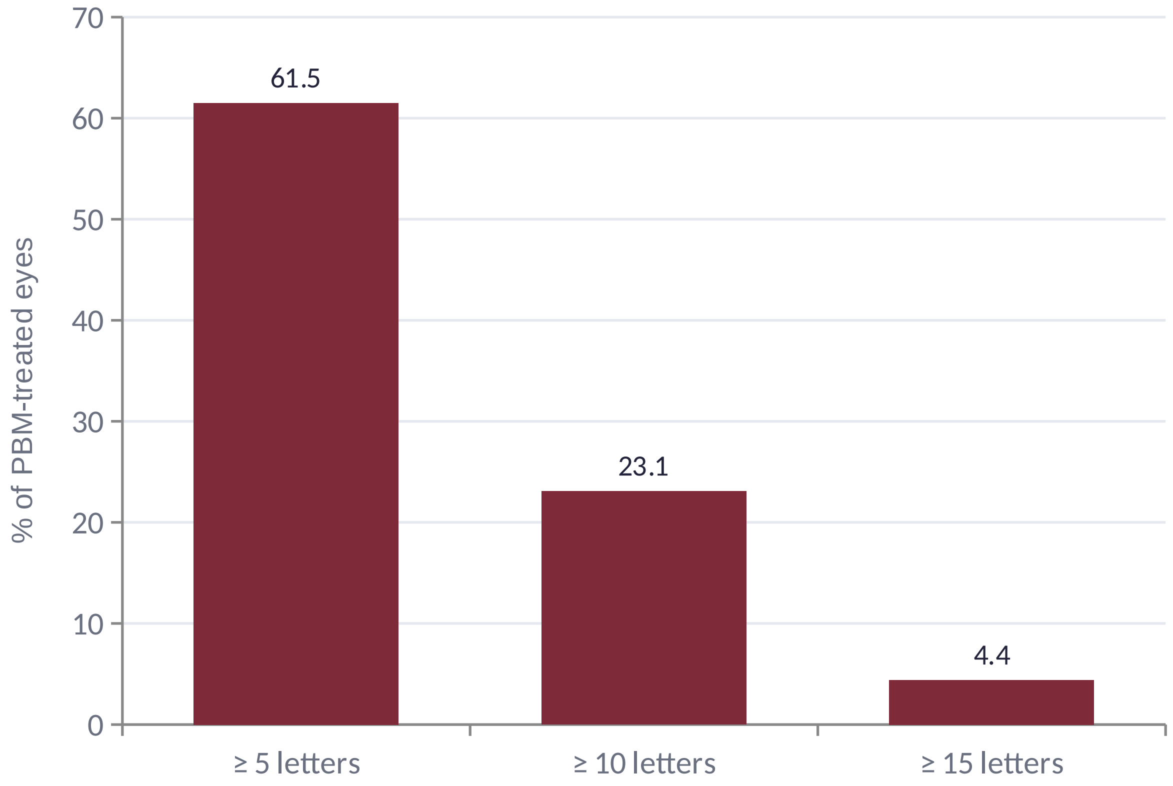
odds ratio for new-onset GA, sham vs. PBM (P = 0.024)

- Significant decrease in new-onset geographic atrophy in the PBM group (Fisher exact test, P = 0.024).
- Favorable safety profile through 13 months — no phototoxicity signal.

Why it matters: letters fluctuate; conversion to GA is the disease milestone patients fear. An anatomic progression signal is the stronger claim — and the one to scrutinize hardest.

Boyer D, et al. Retina. 2024;44(3):487-497.

LIGHTSITE III: 24-Month BCVA and Responder Analysis

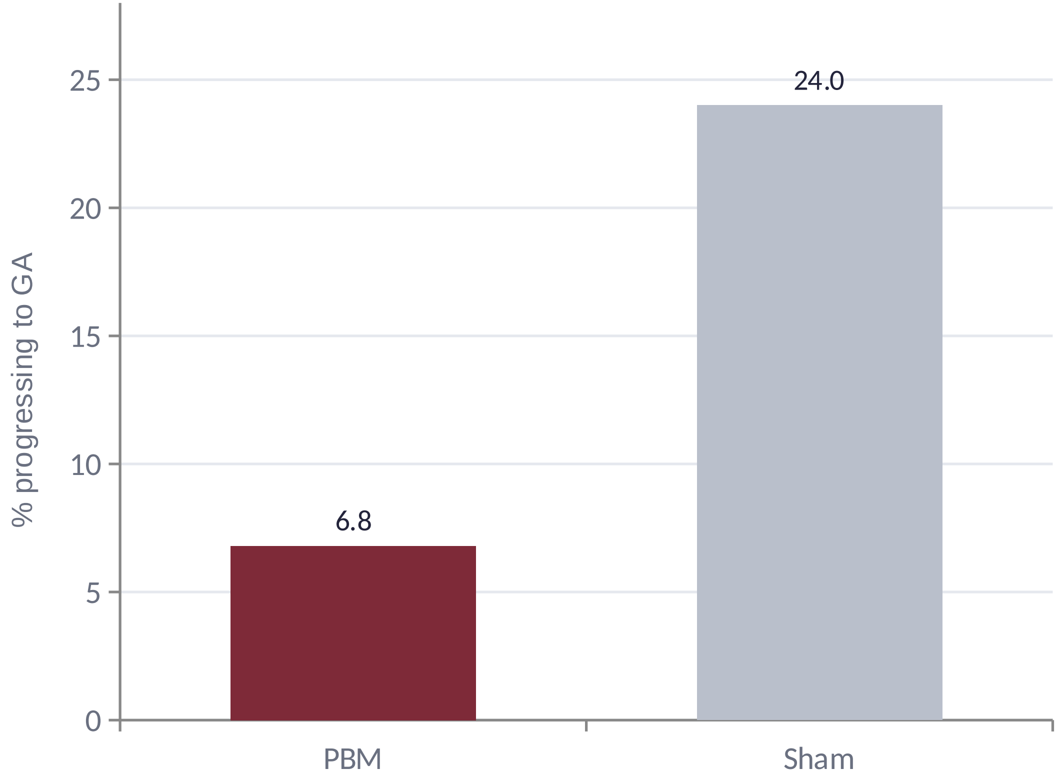


- Prespecified primary BCVA endpoint met at month 21 ($P = 0.0036$).
- Mean gain after PBM: +6.2 letters.
- Majority of treated eyes (61.5%) gained a line or more; a quarter gained two lines.

Post-hoc Cox model: hazard ratio 0.47 for >5-letter BCVA loss over 24 months ($P < 0.02$) — a 53% reduction in onset of vision loss.

Jaffe GJ, et al. Retina. 2026;46(5):783-795 · Do D, et al. Presented at AAO, Chicago, Oct 2024 (post-hoc).

LIGHTSITE III: 24-Month Disease Progression and Safety

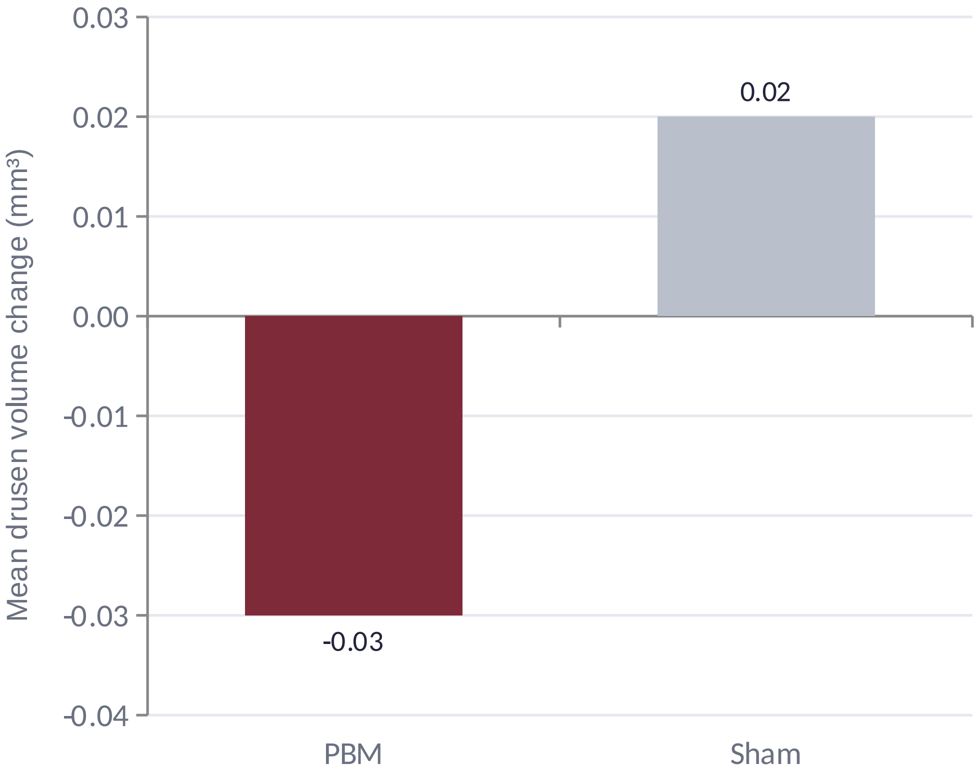


- Progression to geographic atrophy by month 24: 6.8% with PBM vs. 24.0% with sham (P = 0.007).
- Favorable safety profile with no signs of phototoxicity through 24 months.
- Significant benefit in vision-related quality of life.

Post-hoc Cox model: hazard ratio 0.27 for incident GA (P < 0.006) — a 73% risk reduction. Headline claims; the AAO evidence grade two slides ahead asks you to hold them loosely.

Jaffe GJ, et al. Retina. 2026;46(5):783-795 · Do D, et al. Presented at AAO, Chicago, Oct 2024 (post-hoc).

Independent Confirmation: 12-Month Multicentre RCT

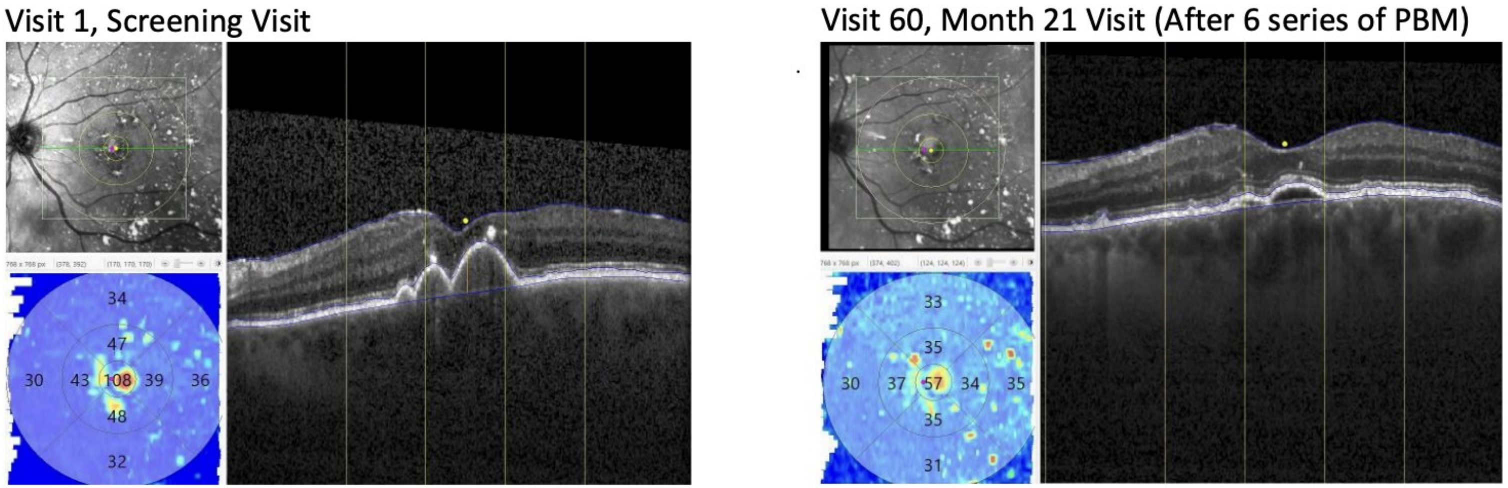


- 138 eyes of 78 patients with early or intermediate dry AMD; double-masked, sham-controlled, multicentre.
- Primary outcome: drusen volume fell with PBM (−0.03 ± 0.05 mm^3) and rose with sham (+0.02 ± 0.04 mm^3); P < .001.
- BCVA: +1.31 letters PBM vs. −2.62 sham — between-group +3.75 letters (95% CI 1.16–6.34; P = .0001).
- Macular neovascularisation: 4 sham eyes vs. 0 PBM eyes (P = .044). Independent of the device sponsor's trial program.

Iovino C, Borrelli E, Coco G, et al. Br J Ophthalmol. 2026 (online first).

One Patient, 24 Months

LIGHTSITE III: Macular Drusen Volume Reduction



Representative OCT imaging from a 77-year-old female subject showing a significant reduction in macular drusen volume after the final series of PBM treatment at Month 21 without visible loss of photoreceptor or retinal pigment epithelium.

Starting BCVA: 75 letters

Month 13 BCVA (4 series of PBM): 79 letters; 4 letter gain

Month 21 BCVA (6 series of PBM): 84 letters; 9 letter gain

Month 24 BCVA (3 months after final PBM Tx): 82 letters; 7 letter gain

The story

- 77-year-old female, dry AMD
- Screening BCVA: 75 letters
- Month 21 (6 series): 84 letters — +9
- Drusen volume visibly reduced on OCT
- No photoreceptor or RPE loss beneath
- This is what “disease modification” looks like on your own OCT

Boyer D, et al. Retina. 2024;44(3):487-497 — representative subject; imaging courtesy LumiThera slide library (used with permission).

Regulatory and Guideline Status: Hold Both at Once

FDA · 2024

Approved the Valeda Light Delivery System for multiwavelength photobiomodulation treatment of patients with non-neovascular AMD — the first interventional authorization in this population.

AAO PPP · 2025

Notes LIGHTSITE I/II and the 2021 Cochrane review did not show benefit, while LIGHTSITE III showed decreased onset of new GA (P = 0.02) — and grades the evidence:

"I−, insufficient quality"

Both statements are true simultaneously. Regulatory authorization is not an evidence grade — and an evidence grade is not a prohibition.

Vemulakonda GA, Bailey ST, Kim SJ, et al. AAO Preferred Practice Pattern. Ophthalmology. 2025;132(4):P1-P74.

Cleared vs. Approved vs. Authorized

CLEARED · 510(k)

- Most Class II (moderate-risk) devices
- Standard: “substantially equivalent” to an existing predicate device
- Typically NO new efficacy trial required
- Eye examples: SLT lasers (Selecta II, Tango Reflex), micropulse lasers (IQ 532, MicroPulse P3), LLLT pain devices

APPROVED · PMA / NDA

- Class III (high-risk) devices — and ALL drugs
- Standard: clinical trial data reviewed for safety AND efficacy
- The most stringent pathway
- Examples: pacemakers, cochlear implants; drugs — anti-VEGF agents, Photrexa, Epioxa

AUTHORIZED · De Novo

- Novel low/moderate-risk device with NO predicate to point to
- Clinical data reviewed; grant CREATES a new device classification
- Future devices may cite it as their predicate
- Valeda: authorized November 4, 2024 (DEN230083) — on the strength of LIGHTSITE III

The patient script: “Not cleared like a laser, not approved like a drug — a first-of-its-kind authorization, with the trial we just walked through behind it.”

FDA: 510(k), PMA, and De Novo program descriptions · FDA De Novo DEN230083 (Valeda), Nov 4, 2024.

Read the Label: Authorization Is Narrower Than the Trial

Labeled indication

- BCVA 20/32 through 20/70 — narrower than the trial's 20/100 floor
- ≥3 medium drusen (>63–≤125 µm), or large drusen (>125 µm), or non-central GA
- No neovascular maculopathy; no center-involving GA

Label's own claim: ~1 line of ETDRS acuity vs. no treatment at ~2 years.

Contraindications & precautions

- Known photosensitivity to yellow, red, or near-infrared light
- History of light-activated CNS disorders (e.g., epilepsy, migraine)
- No treatment within 30 days of photosensitizing agents affected by 590/660/850 nm, absent physician consultation
- Benefit may not persist after stopping; no data beyond 54 treatments per eye

Prescribe to the label; counsel to the trial; monitor to both.

FDA De Novo DEN230083; Valeda Light Delivery System Indications for Use / Important Product Information.

Patient Selection: Mirror the Trial Population

- ✓ Intermediate non-neovascular AMD
- ✓ BCVA 20/32–20/100 in the trial; 20/32–20/70 on the label
- ✓ No center-involving geographic atrophy
- ✓ No active or prior exudative disease in the treated eye
- ✗ Established center-involving GA → complement-inhibition discussion instead
- ✗ Exudative conversion at any point → anti-VEGF pathway, not PBM

KEY POINT Selection discipline is the ethical core of offering this therapy — the data exist only for the enrolled phenotype.

Boyer D, et al. Retina. 2024 · Jaffe GJ, et al. Retina. 2026.

The Device in the Room

What staff see

- Tabletop unit — slit-lamp posture, chin rest
- Touchscreen walks the 4 phases
- Live view of the treated eye
- ≈ 4 min per eye; no dilation
- 590 / 660 / 850 nm LEDs — the three dots on every slide today

Valeda Light Delivery System (LumiThera → Alcon). Photos: LumiThera clinical library, used with permission.

Treatment Protocol in Practice

Series	9 sessions over 3–5 weeks — three per week is the preferred cadence
Re-treatment	Repeat the full series approximately every 4 months — benefit wanes without it
Delivery	590 + 850 nm pulsed (open eye); 660 nm continuous (closed lid) — alternating phases
Dose	Device outputs 5 / 65 / 8 mW/cm² at 590 / 660 / 850 nm; 250 s per eye; no dilation
Chair time	About 4 minutes per eye — delegable after training

Jaffe GJ, et al. Retina. 2026 · Device outputs: manufacturer specifications (Valeda User Manual).

Workup and Monitoring: Match the Trial Endpoints

- **BCVA (ETDRS if available)** — the functional primary endpoint
- **Contrast sensitivity** — often moves before acuity
- **OCT with drusen volume analysis** — the anatomic endpoint that changed in both RCT programs
- **Fundus autofluorescence** — geographic atrophy mapping — the progression milestone
- **OCT-A where available** — surveillance for neovascular conversion

KEY POINT If you cannot measure the trial endpoints, you cannot verify the trial benefit in your patient.

Iovino C, et al. BJO 2026 · Jaffe GJ, et al. Retina 2026.

Patient Counseling: The Five Sentences

1. *“This is a maintenance therapy, not a cure — the benefit fades if we stop the every-four-month series.”*
2. *“It does not replace your AREDS2 vitamins, smoking cessation, or monitoring.”*
3. *“If your AMD ever converts to the wet form, anti-VEGF injections take priority — this does not substitute.”*
4. *“In the pivotal trial, treated eyes gained about six letters by two years — and untreated eyes also improved somewhat, so the added benefit is real but modest.”*
5. *“The strongest signal is fewer eyes progressing to atrophy — about 7% versus 24% at two years.”*

Boyer D, et al. Retina. 2024;44(3):487-497.

Practice Logistics

Chair time

Short sessions, but 9 visits × 3 series/year per patient — model the schedule before buying

Staffing

IPL/LLLT delegable per state law — but retinal PBM must be personally performed by an OD/MD/QHP (MAC guidance, next slides)

Scheduling

Recurring 4-month series blocks; recall systems matter more than the device

Reimbursement

CPT 0936T live since Jan 2025; MAC-priced claim-by-claim — ABN workflow + transparent self-pay backstop (next slides)

Follow the Money I: CPT 0936T Arrives

The code

0936T — “Photobiomodulation therapy of retina, single session” · effective Jan 1, 2025 · session = one day · bilateral: modifier -50 per CPT

The payment

No national fee schedule amount — each MAC prices claim-by-claim; varies by region & payer. 2025 experience: many claims paid

The coverage

No LCDs yet; ≥ 1 national commercial policy lists 0936T non-covered → ABN on every Medicare patient; self-pay backstop

The provider

Personally performed by OD / MD / QHP — MAC medical directors (Mar 2025): NOT MAs or techs, even supervised. Incident-to 100% vs 85%

Diagnosis coding: ICD-10 H35.31- (nonexudative AMD) · 6th digit = eye · 7th digit: 1 early, 2 intermediate — on-label = intermediate.

Straight From the Biller's Mouth: 0936T in NEPA

Paying

- **Medicare:** $272.55 allowable per session; $45.44 coinsurance to patient or secondary
- **Humana MA:** $228 paid; patient $40 copay
- **UnitedHealthcare:** $121.26 per eye; patient $35 copay

Secondaries covering the 20%

- HOP
- AARP
- Some Blue Cross plans
- GHI — leaves a $15 copay
- Some Aetna plans
- Mutual of Omaha
- Bankers

Denies — no matter what

- Tricare
- Medical Assistance (Medicaid)
- Veterans Assistance
- Geisinger

The workflow this dictates: verify plan-by-plan BEFORE session one, ABN every Medicare patient, and collect the known copay at check-in — not after nine visits.

Source: our billing team — adjudicated claims, our practice, Novitas jurisdiction (PA), as of Sept 2026. Regional experience; your MAC and plan mix will differ.

The Napkin Version

MONEY IN	≈ $2,450	one Medicare patient course: 9 sessions × $272.55
MONEY OUT	– $270–450	consumable cost for that course (volume tier)
WHAT STAYS	≈ $2,000–2,180	gross margin per completed course
THE BOX	$75–90K → ≈ 35–45 courses	device cost ÷ what stays = break-even

One sentence: a Medicare course nets about two grand — and the machine costs about forty of those. The real constraint is doctor minutes, because 0936T must be personally performed.

Arithmetic from our Medicare experience ($272.55/session, 9-session course) and vendor consumable tiers ($270–450/course). Illustrative; excludes staff time, financing, and rent.

Follow the Money II: Unit Economics (Illustrative)

Disclaimer: educational arithmetic only — not pricing guidance, not fee coordination. Inputs are public/vendor estimates or hypothetical. Every practice sets its own fees independently.

The cost stack

- Device capital: ≈ \$75–90K (market estimate)
- Per-treatment fee (tiered by volume): ≈ \$50 → \$30 (\$450 → \$270 per 9-treatment course)
- On-label year: 3 series × 9 = 27 treatments → consumables ≈ \$810–\$1,350 / treated year
- Confirm with vendor: per EYE or per PATIENT — and terms continue to change

Device payback — illustrative

Courses to recover capital = capital ÷ [9 × (net revenue/session − click fee)]

Net \$/session (hypothetical)	Courses to break even	≈ Patient-years
\$150	≈ 70–100	≈ 23–33
\$250	≈ 38–50	≈ 13–17

(Uses click fee \$50 → \$30 across volume tiers; 3 courses ≈ 1 patient-year)

The real cost line: doctor minutes. PBM is personally performed — every session competes with exam-lane revenue. IPL delegation math does not transfer.

Device cost & per-treatment fees: market estimates, subject to change · Corcoran KJ. Retinal Physician. 2025.

Investigational Frontiers — Every Item Off-Label

Diabetic macular edema

Case-level reduction in central retinal thickness and hard exudates

Central serous chorioretinopathy

Case-level subretinal fluid resolution, maintained at ~1 year

Reticular pseudodrusen

SD-OCT stage regression at 6 months in case series

Retinitis pigmentosa

Early pilot investigation only

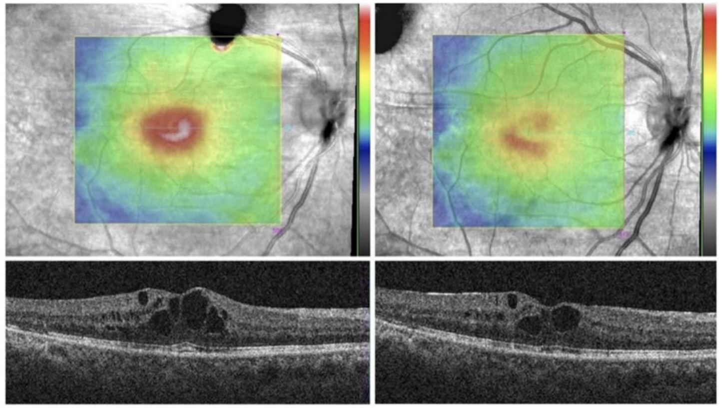
Evidence tier: case reports and pilot series only — hypothesis-generating, not practice-changing. All uses off-label. (Glaucoma: next slide.)

Kaymak H, et al. Clin Ophthalmol. 2023 · Sachdev A, et al. Ophthalmol Ther. 2024 · Le HM, et al. Medicina (Kaunas). 2022 · Siqueira RC. Clin Ophthalmol. 2024.

Frontiers, Illustrated I: DME & Central Serous

Investigator-Initiated Clinical Support

Valeda Improves Clinical Outcomes in Diabetic Macular Edema (DME)

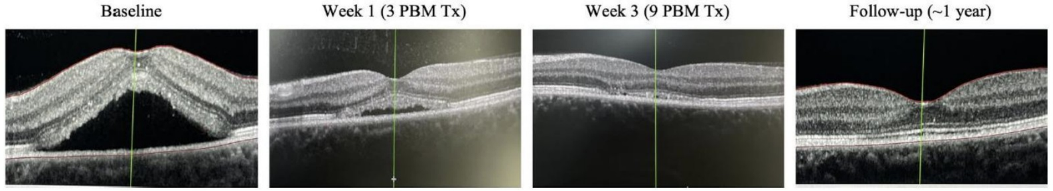


Reduction of central retinal thickness (CRT) in DME patient following Valeda treatment. OCT imaging for the selected subject showed a reduction of CRT and hard exudates following PBM treatment.

Kaymak et al., Clinical Ophthalmol, 2023

Investigator-Initiated Clinical Support

Valeda Improves Clinical Outcomes in Central Serous Chorioretinopathy



Valeda reduces central serous chorioretinopathy pathology following PBM treatment. Imaging scans show resolution of pathology from baseline, during the PBM treatment series, and at ~ 1-year follow-up.

Schdev, A., Ophthalmol Ther, 2024

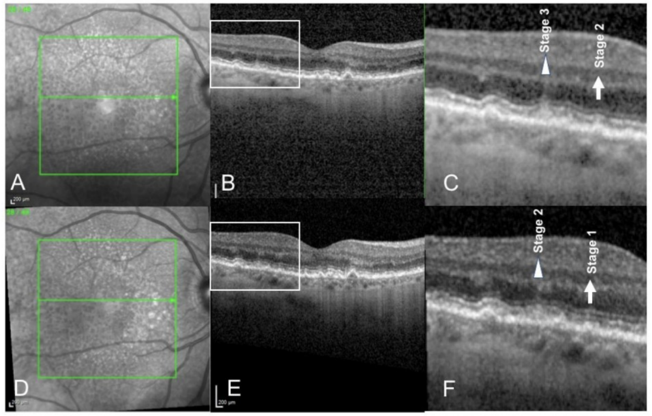
Same rules as the last slide: case-level imaging, off-label — this shows biological plausibility, not efficacy. But it is why the trials are being run.

Kaymak H, et al. Clin Ophthalmol. 2023 · Sachdev A, et al. Ophthalmol Ther. 2024 — imaging via LumiThera library (used with permission).

Frontiers, Illustrated II: RPD & Drusenoid PED

Investigator-Initiated Clinical Support

Valeda Improves Anatomical Outcomes in Reticular Pseudodrusen (RPD)

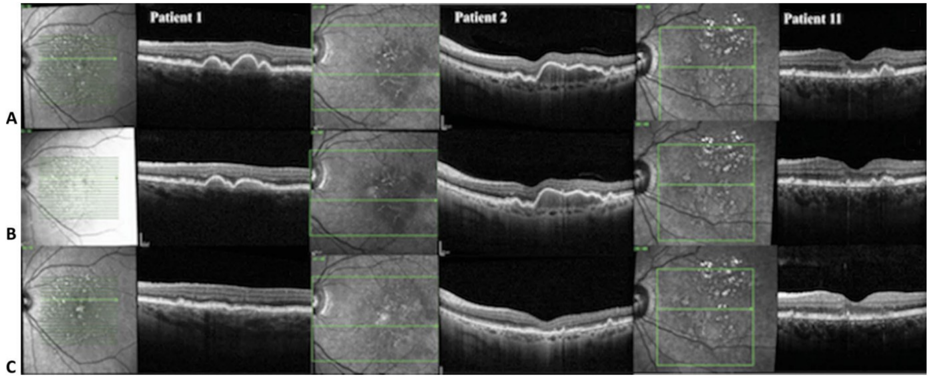


SD-OCT scans of a 76-year-old female patient presenting with with RPD, before (A–C) and 6 months after Valeda treatment (D–F). Infrared imaging (A,D). SD-OCT scan showing RPD before (B) and after (E) treatment. Stage 3 RPD (triangle, (C)) regressed into a stage 2 (triangle, (F)) RPD 6 months after treatment. Similarly, a stage 2 RPD (arrow (C)) regressed into a stage 1 RPD (arrow, (F)) 6 months after treatment.

Le et al., Medicina (Kaunas), 2022

Investigator-Initiated Clinical Support

Valeda Improves Anatomical Outcomes in AMD



B-scan OCT demonstrating drusen reduction in dry AMD treated by Valeda. Baseline (A) imaging showing large macular drusenoid pigment epithelial detachment (PED) in patients 1 and 2 and soft drusen in patient 11. Week 5 (B) B-scan SD-OCT showing drusen volume evolution with a main reduction at the time points between week 5 and month 6. Month 6 (C) imaging illustrates the complete reduction of the drusenoid PED and soft drusen after a series of 10 Valeda treatments.

Benlahibib et al., Retina, 2023

Pattern to notice: across four different lesion types, the imaging moves the same direction — structures regress without atrophy underneath. Mechanism-consistent, trial-unproven.

Le HM, et al. Medicine (Kaunas). 2022 · Benlahbib M, et al. Retina. 2023 — imaging via LumiThera library (used with permission).

Glaucoma: Compelling Biology, Zero Human Trials

Why it SHOULD work

- RGCs: among the most mitochondria-dense neurons in the body
- Glaucoma has a recognized bioenergetic component beyond IOP
- CCO-targeted therapy meets an energy-failure disease — the AMD logic, one synapse upstream

Preclinical signal

- Red light attenuated RGC death in culture and in situ (2016)
- Optic nerve crush, 660/830 nm: PhNR amplitude ≈ +39% vs untreated (ARVO 2025)
- Rat NAION, 670 nm: ≈ 1.6× RGC survival; > 3× FVEP amplitude; apoptosis ↓
- OHT models: RGC & optic-nerve architecture preserved; Bcl-2 ↑, Bax / caspase-9 ↓

Human evidence

- No adequate randomized trials
- Only tiny non-randomized series
- PBM does not lower IOP — adjunctive neuroprotection at best
- Nothing practice-relevant today

Evidence tier: preclinical only — a rung BELOW the case reports on the previous slide. This is AMD at the TORPA stage: on the disclosure slide, off the treatment plan.

Del Olmo-Aguado S, et al. Acta Ophthalmol. 2016;94:e481-e491 · IOVS (ARVO) 2025 abstract · Chun JM, et al. Front Med. 2026;13:1904150.

Counterpoint: Red Light Is Not Inherently Benign

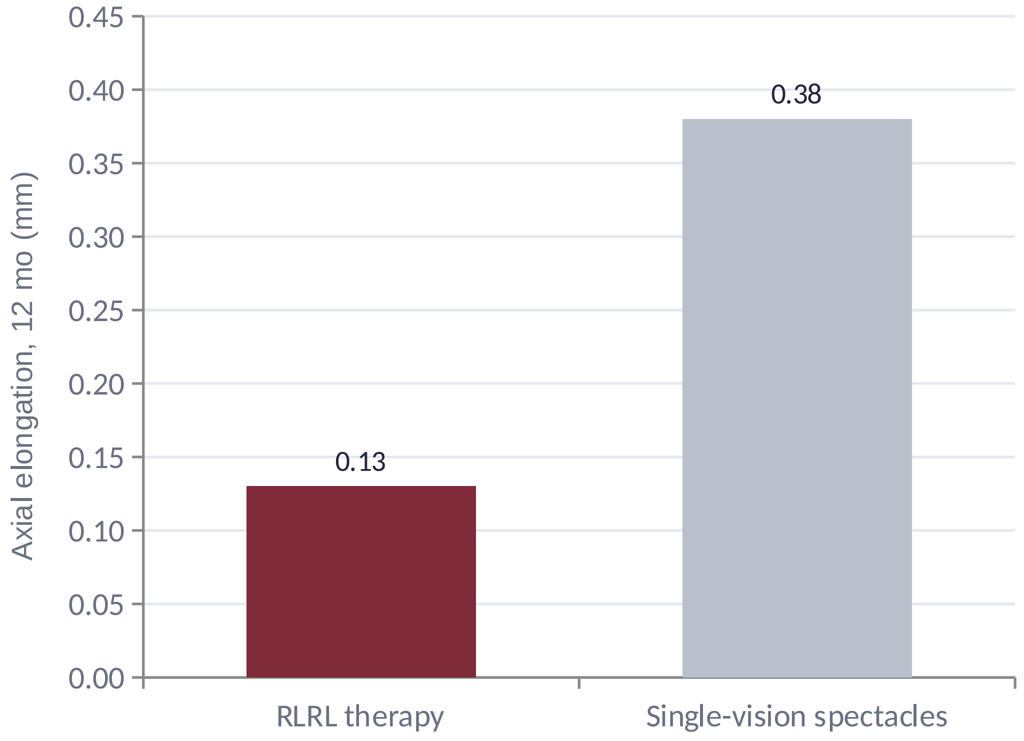
Documented harms with repeated red-light exposure (myopia-control context, off-label)

- 12-year-old: foveal injury and macular hypoautofluorescence after repeated red laser therapy — bilateral ellipsoid-zone disruption on OCT; only partial visual recovery after cessation
- Separate report: reduced cone photoreceptor density after 1 year of treatment
- One study: structural OCT changes in 7% of children after 1–6 months of treatment

[Insert licensed OCT figure: bilateral EZ disruption at the fovea, partial recovery 3 months after discontinuation — Liu et al., Figure 2]

Device bench testing has also found some consumer units exceeding assumed exposure classes (Ostrin & Schill 2026).

…But the Larger Datasets Are Reassuring



- 246-child multicenter RCT: no severe adverse events, no functional visual loss, no structural OCT damage at 12 months.
- Double-masked, sham-controlled RCT: no treatment-related adverse events.
- 336-child randomized trial: masked fundus photograph review identified no retinal changes in either group.

Resolution: the tension is unresolved — device characteristics and dosimetry, not the color of the light, determine safety.

CLOSING

Key Takeaways

1	**Physics governs everything**	Wavelength selects the chromophore; dose determines the direction of effect — the biphasic response is the master rule.
2	**Anterior segment**	IPL and LLLT both carry randomized support in MGD, are frequently synergistic, and improve symptoms and function — without reversing gland dropout.
3	**Posterior segment**	Multiwavelength PBM is the first FDA-authorized interventional option for non-neovascular AMD — positive 24-month randomized and independent 12-month data, tempered by an AAO evidence grade of I−, insufficient quality.
4	**The field's unmet need**	Standardization of parameters — without it, every device comparison and every meta-analysis stays muddy.

Questions & Discussion

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Full reference list available on request — and appended to this deck.

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