Mechanics, Aging and Neurological Control of accommodation:

I. Multiple Mechanisms of Accommodation

A. Variable axial length

B. Corneal Power

C. Lenticular power

D. Pupil size

E. Lenticular refractive index gradient (isoindical surfaces)

II. Anatomy

A. Lens

B. Capsule

C. Zonules

D. Ciliary Body

E. Index gradient

III. Autonomic innervation

IV. Amplitude of accommodation and age

A. Functional presbyopia

B. Absolute presbyopia

C. Treatment

Bifocals

Monovision

Surgically implanted prosthesis

Course title- (VS217)
Oculomotor functions and neurology

Instructor - Clifton Schor

GSI:
James O'Shea, Michael Oliver & Aleks Polosukhina
Schedule of lectures, exams and laboratories:
Lecture hours 10-11:30 Tu Th; 5 min break at 11:00
Labs Friday the first 3 weeks

Examination Schedule:

Quizes: January 29; February 28

Midterm: February 14: Final March 13

Power point lecture slides are available on a CD

Resources:
text books, reader, website, handouts

Class Website:
Reader. Website http://schorlab.berkeley.edu
Click courses
117 class page
name VS117
password Hering,1

First Week: read chapters 16-18
See lecture outline in syllabus
Labs begin this Friday, January 25

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A-IOL Model

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BINOCULAR VISION RESEARCH

THE SCHOR LAB

University of California
Berkeley

Hi! Welcome to the laboratory of Dr. Clifton Schor at the University of California-Berkeley. To find out more about what we do, follow one of the links below, or use the menu on the left for a more detailed tour through the lab.

Lab Overview one: What we do in layman's terms	UCB Optometry	**Lab overview two:** What we do in more technical terms (includes recent projects and ARVO abstracts)

Course Goals

Near Response-

<u>Current developments in optometry</u>

Myopia control –

environmental, surgical, pharmaceutical and genetic

Presbyopia treatment – amelioration and prosthetic treatment

Developmental disorders (amblyopia and strabismus)

Reading disorders

Ergonomics- computers and sports vision

Virtual reality and personal computer eye-ware

Neurology screening- Primary care gate keeper

neurology, systemic, endocrines,

metabolic, muscular skeletal systems.

Mechanics, Aging and Neurological Control of accommodation:

I. **Five Mechanisms of Accommodation**

A. Variable axial length

B. Corneal Power and astigmatism

C. Lenticular power

D. Pupil size & Aberrations

E. Lenticular refractive index gradient (isoindical surfaces)

II. **Anatomy & Mechanics**

A. Lens

B. Capsule

C. Zonules

D. Ciliary Body

E. Index gradient

III. **Autonomic innervation**

IV. **Amplitude of accommodation and age**

A. Functional presbyopia

B. Absolute presbyopia

C. Treatment

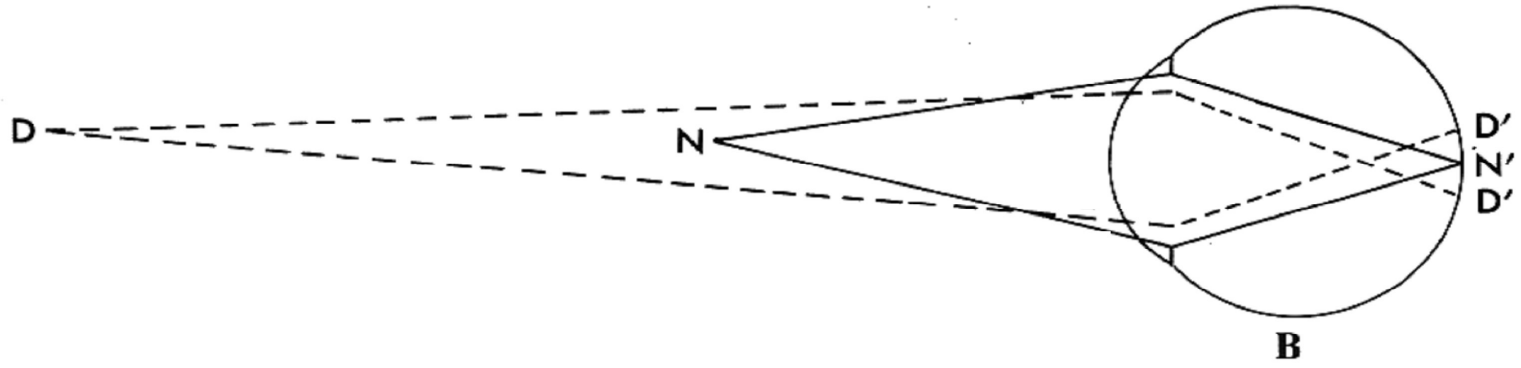
Reduced pupil size

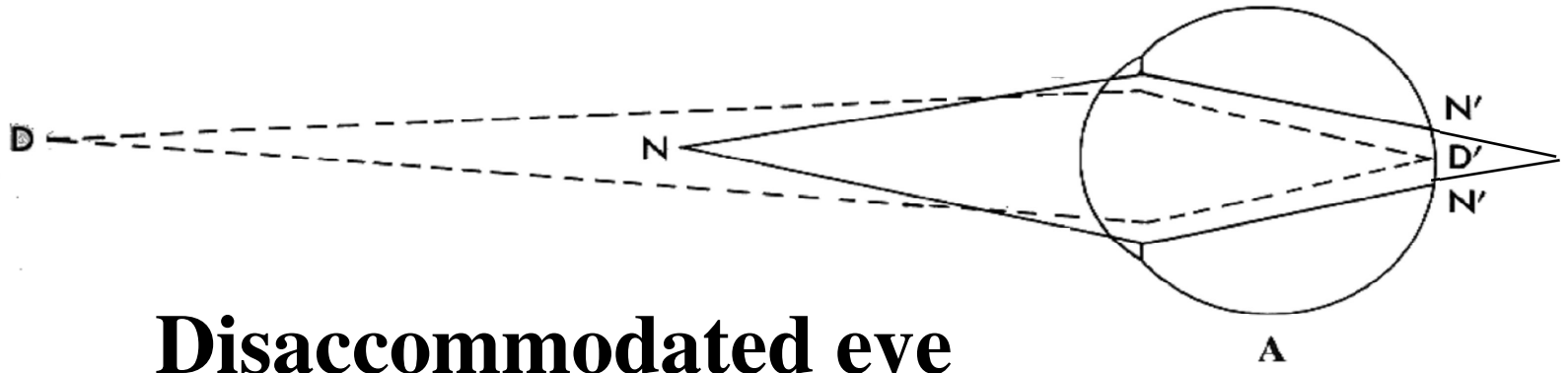
Bifocals

Monovision

Surgically implanted prosthesis

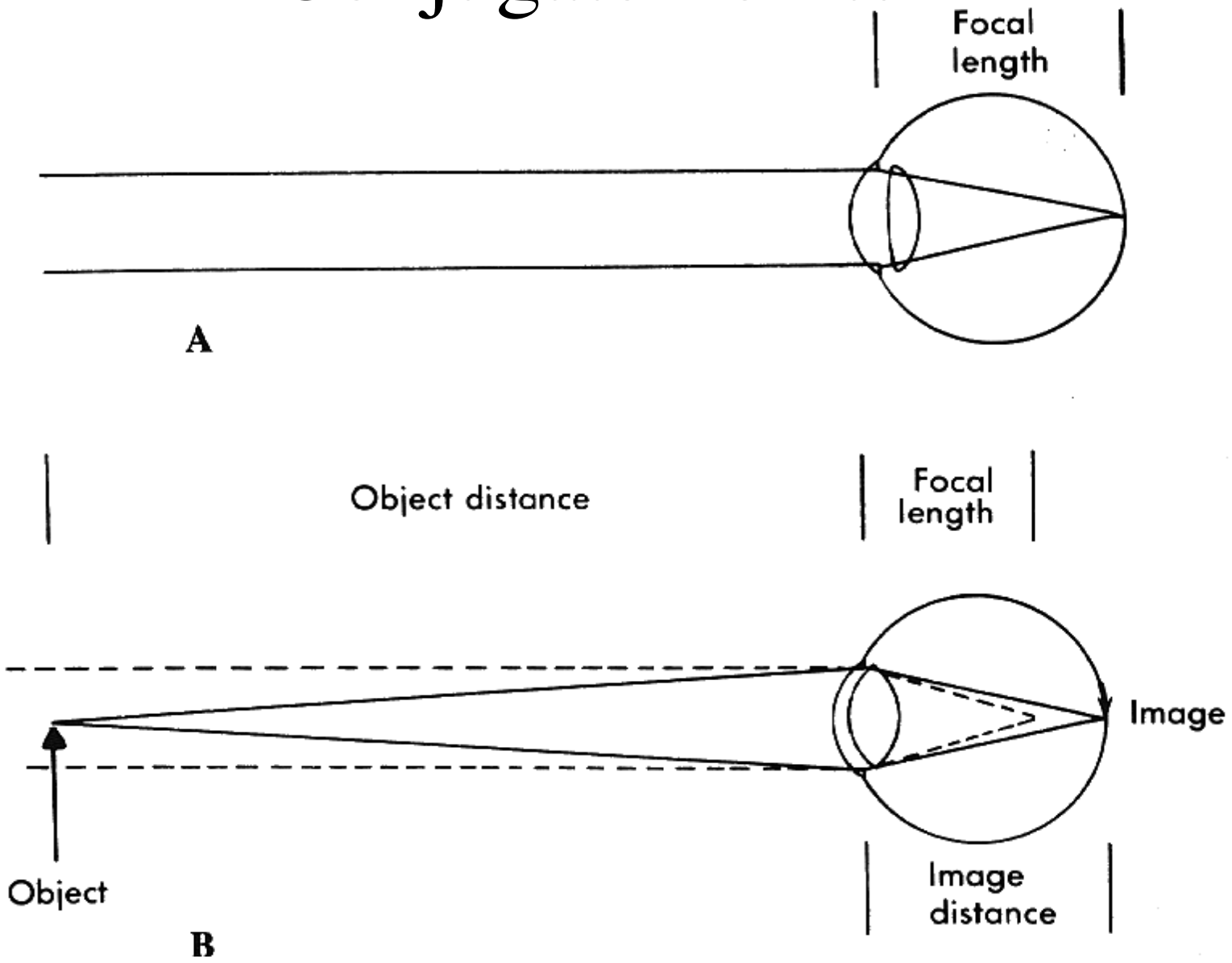
Accommodated eye





Disaccommodated eye

Conjugate Points



Definitions:

1) Accommodation = the ability to focus images of objects at various distances in space onto the retina.

2) Accommodation = the ability to make objects at various distances in space conjugate to the retina.

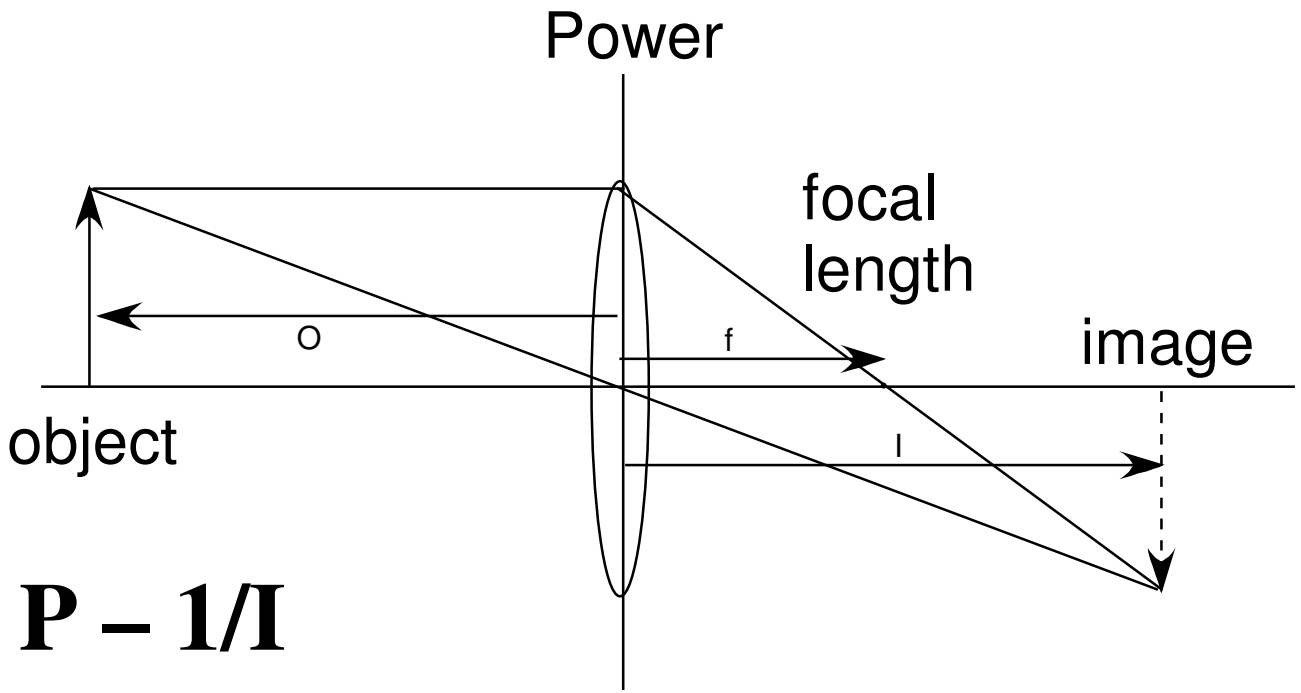
3) Conjugacy = mathematical term that describes pairing of points or interchangeable points in a function.

This principle is the basis of ophthalmoscopy (viewing the retina) and retinoscopy

Objects and images, described for an optical system by the Gaussian equation, are conjugate (i.e. objects and images are interchangeable). $\mathbf{1/O + 1/I = 1/f}$

Conjugacy described by the Gaussian equation

$$P = 1/f = 1/O + 1/I$$



$$\mathbf{1/O = P - 1/I}$$

O = Object distance in space to the cornea

I = Axial length of the eye, or image plane (screen) distance from cornea

F = Optical power of the eye (lens + cornea) referred to cornea location

Changes that could focus the retinal image:

O = Object distance in space from the cornea

I = Axial length of the eye, or image plane (retinal screen) distance from the cornea

F = Optical power of the eye (lens + cornea) referred to the cornea (60D)
i.e. 1/ focal length

Accommodation can work by changing any one of these 3 parameters.

Mechanisms of Accommodation

Axial length

24 mm adult, 17 mm neonate

Cornea is more powerful in neonate and reduces as the axial length increases because the **radius of curvature expands** with eye growth.

1mm axial change of axial length = 5 D
Myopes have long eyes.

Emmetropization A process that keeps optics matched to axial length. Ocular growth is stimulated by blur during the first two decades of life.

Eel's have accordion eyes that change axial length by ocular compression

Corneal Power

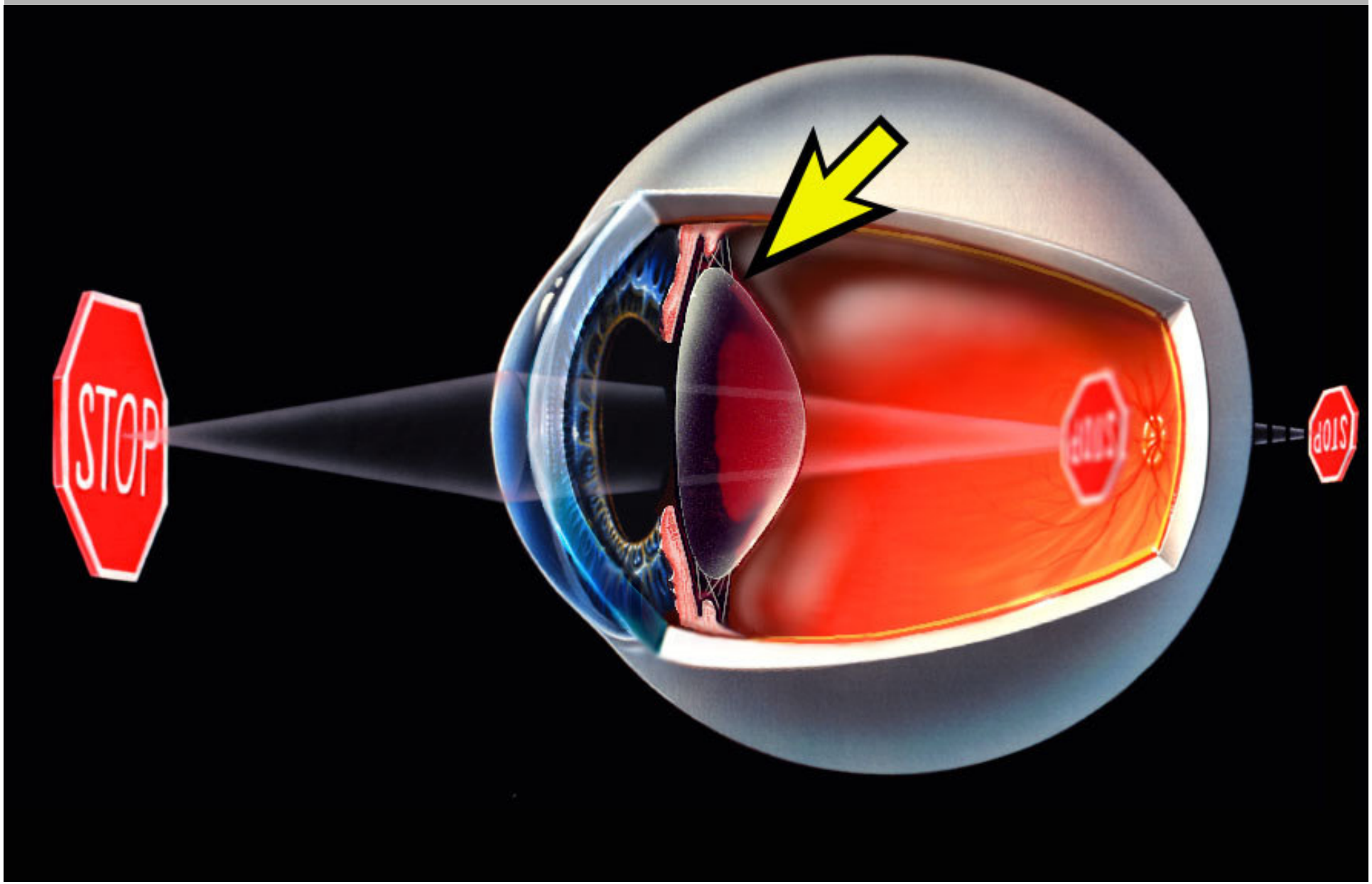
Eel and Owls flatten the cornea to see far away.

If we are myopes, we squint (narrow our palpebral aperture) to see far away.

Corneas of infant eyes flatten with eye growth and elongation of the eye during emmetropization.

Corneal astigmatism has a range of focal distances between the two major meridians.

Lenticular Accommodation



Compression of lens by iris can change power by over 40D

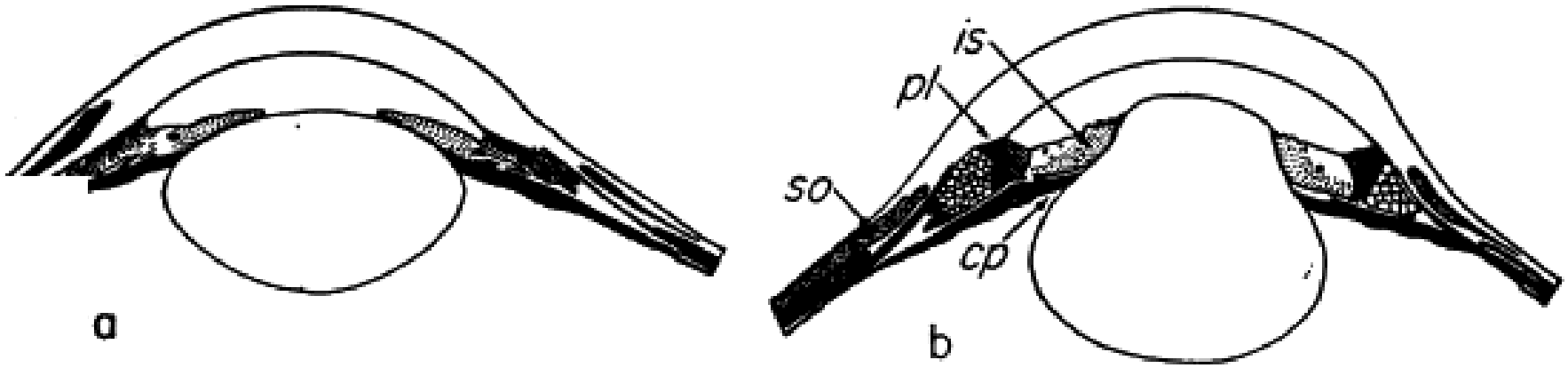
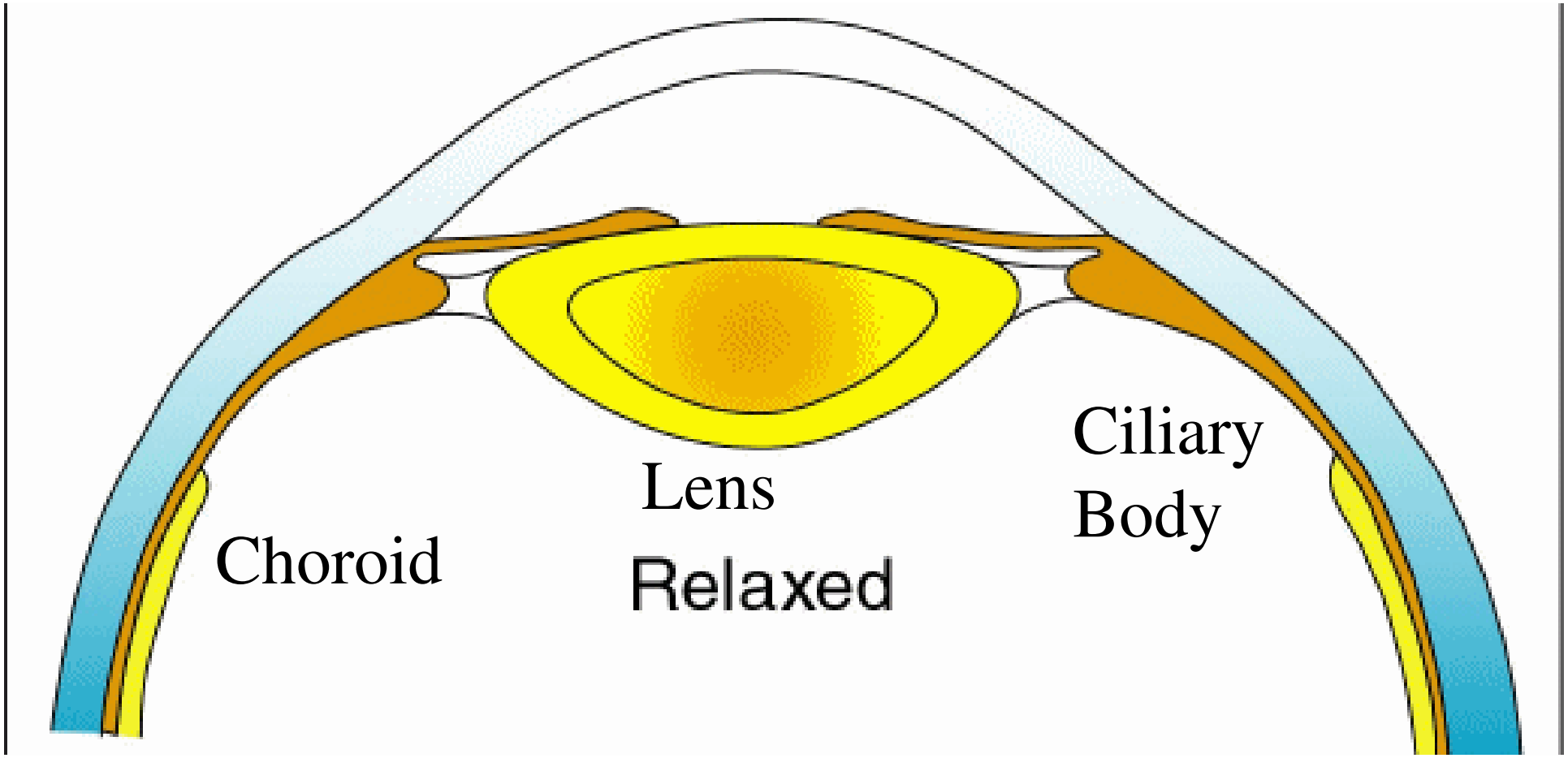
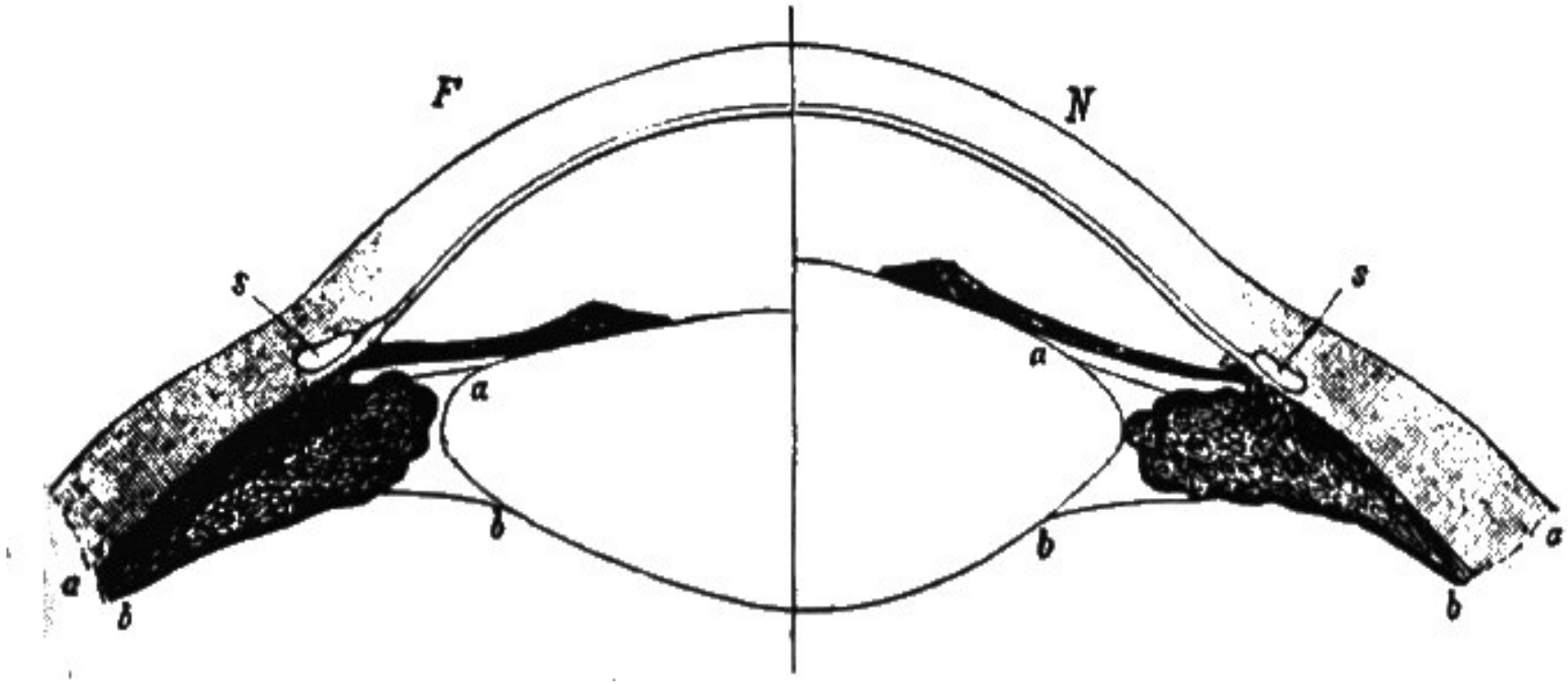


Fig. 149—Accommodation in amphibious birds.

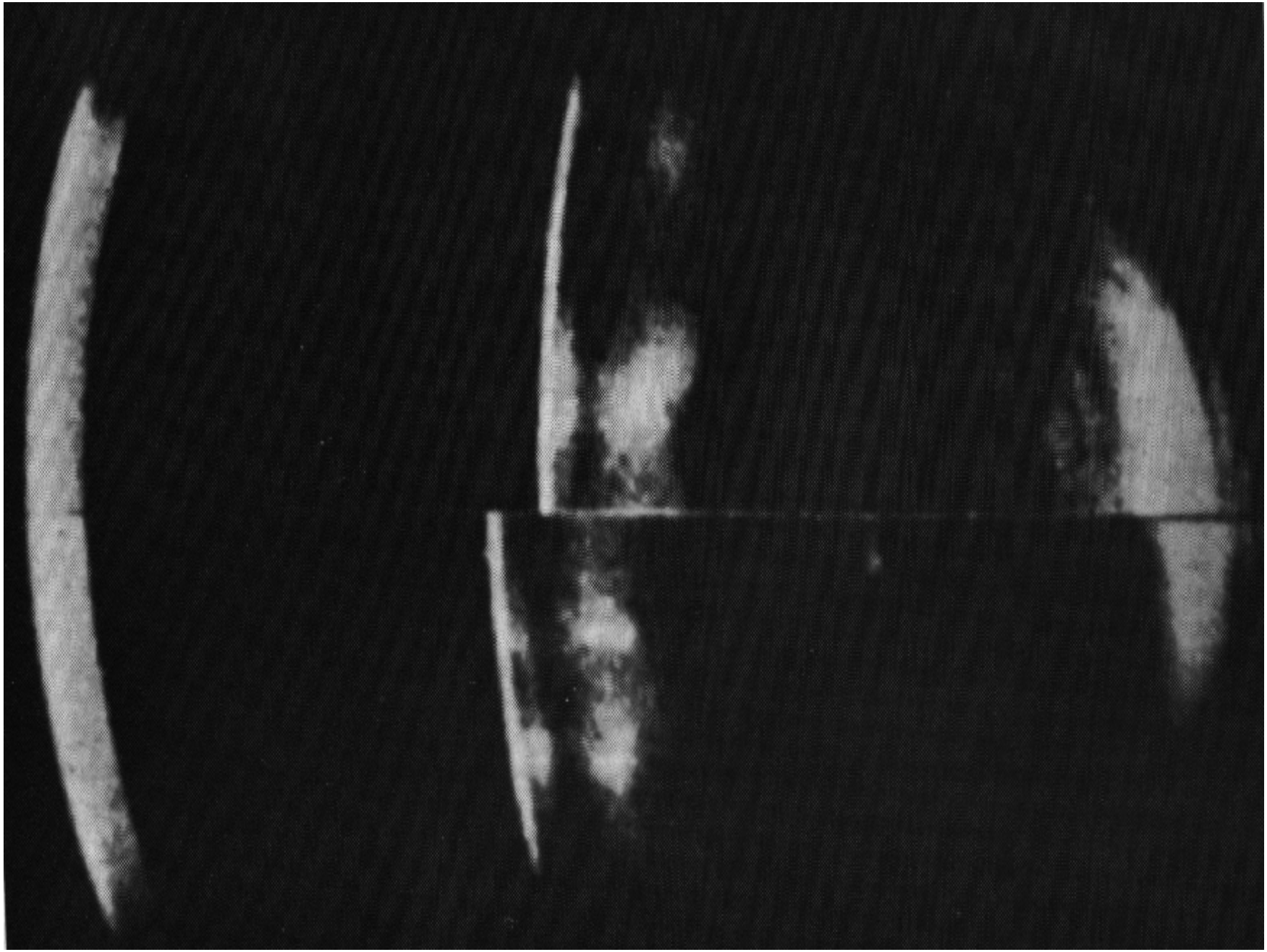

Choroid
Lens
Relaxed
Ciliary
Body



During accommodation

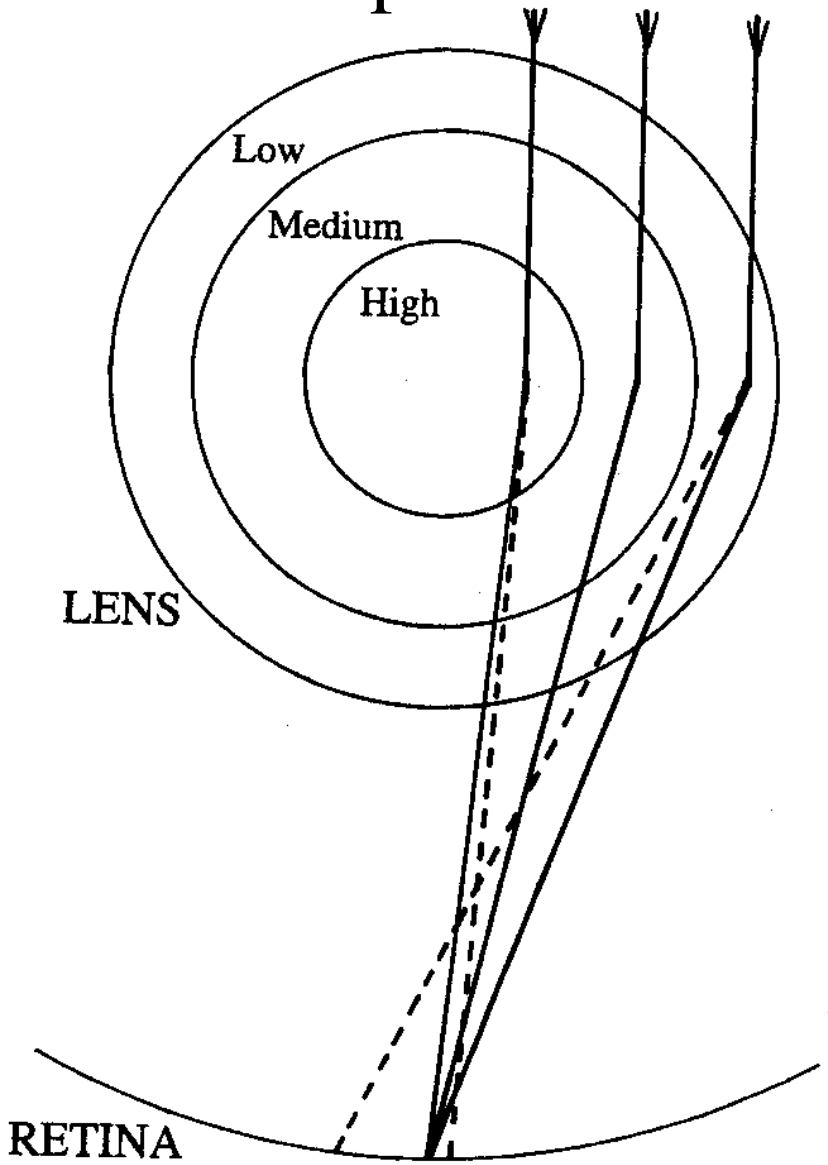
1) Lens thickness increases by 0.5 mm during accommodation

2) Lens nucleus changes thickness more than the cortex.

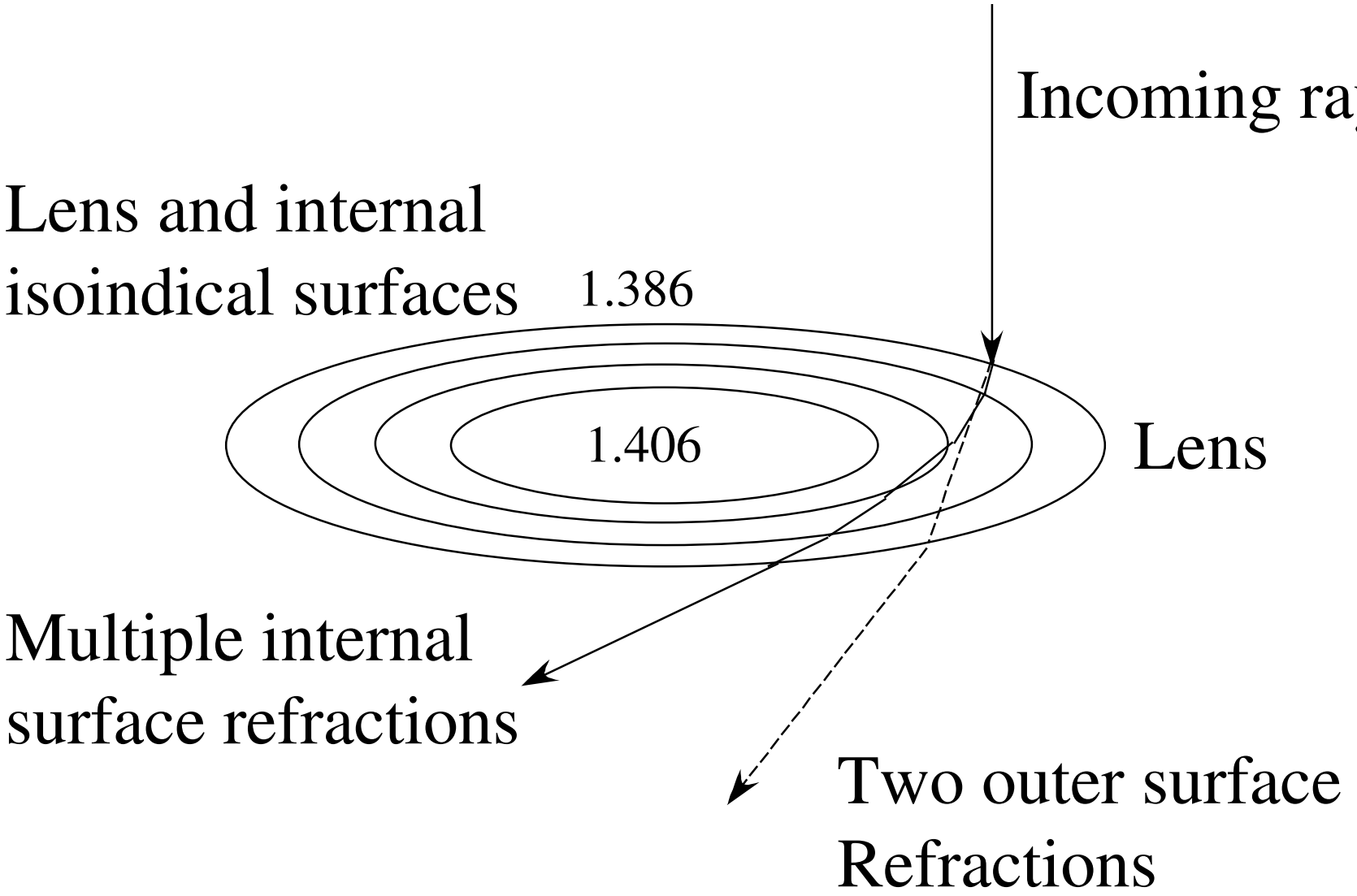


Lens translation is used by cats, and by humans with prosthetic accommodating intraocular lenses.

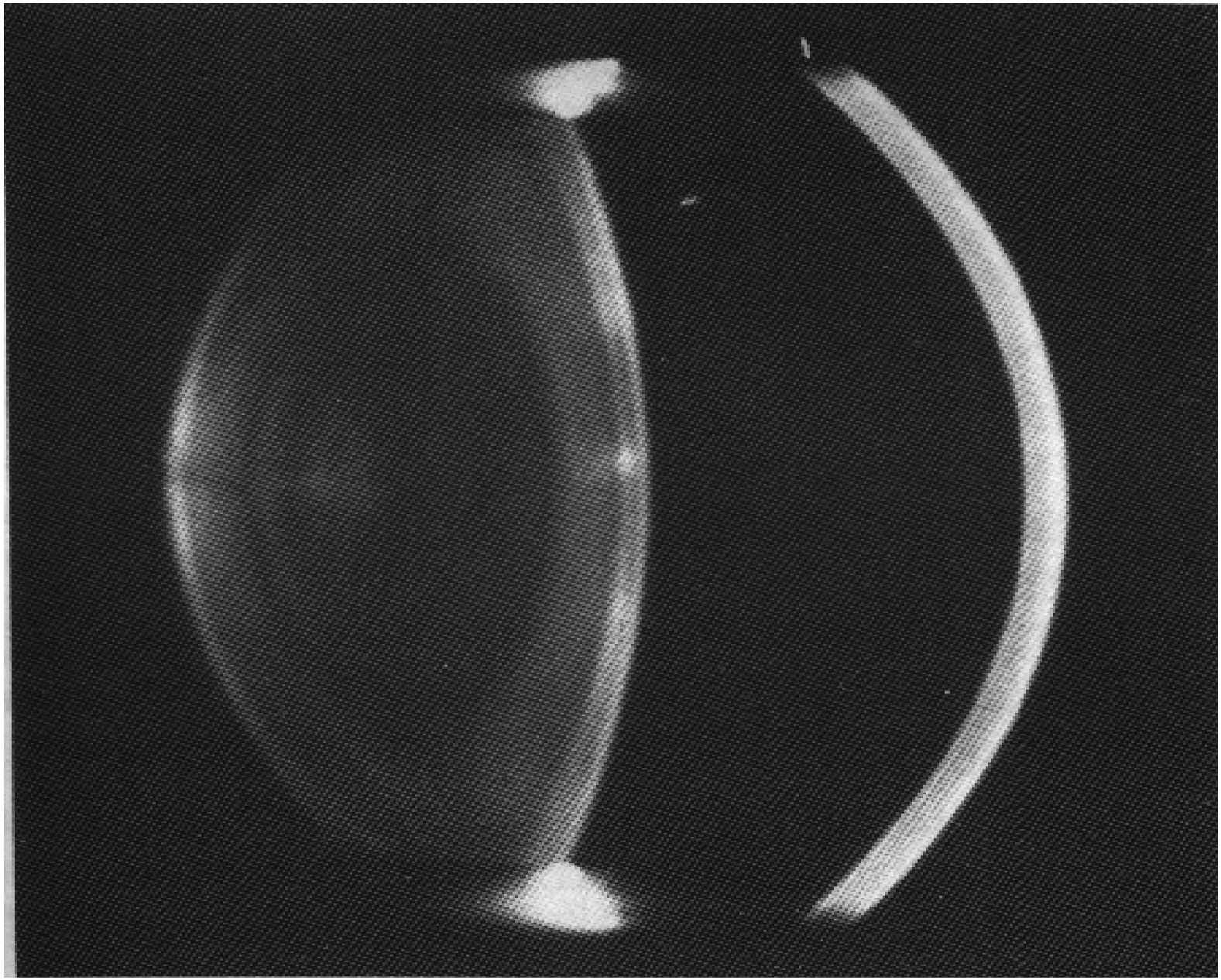
Refractive index gradient reduces spherical aberration and increases refractive power with internal refraction



Refractive index gradient increases refractive power with internal refraction & reduces spherical aberration

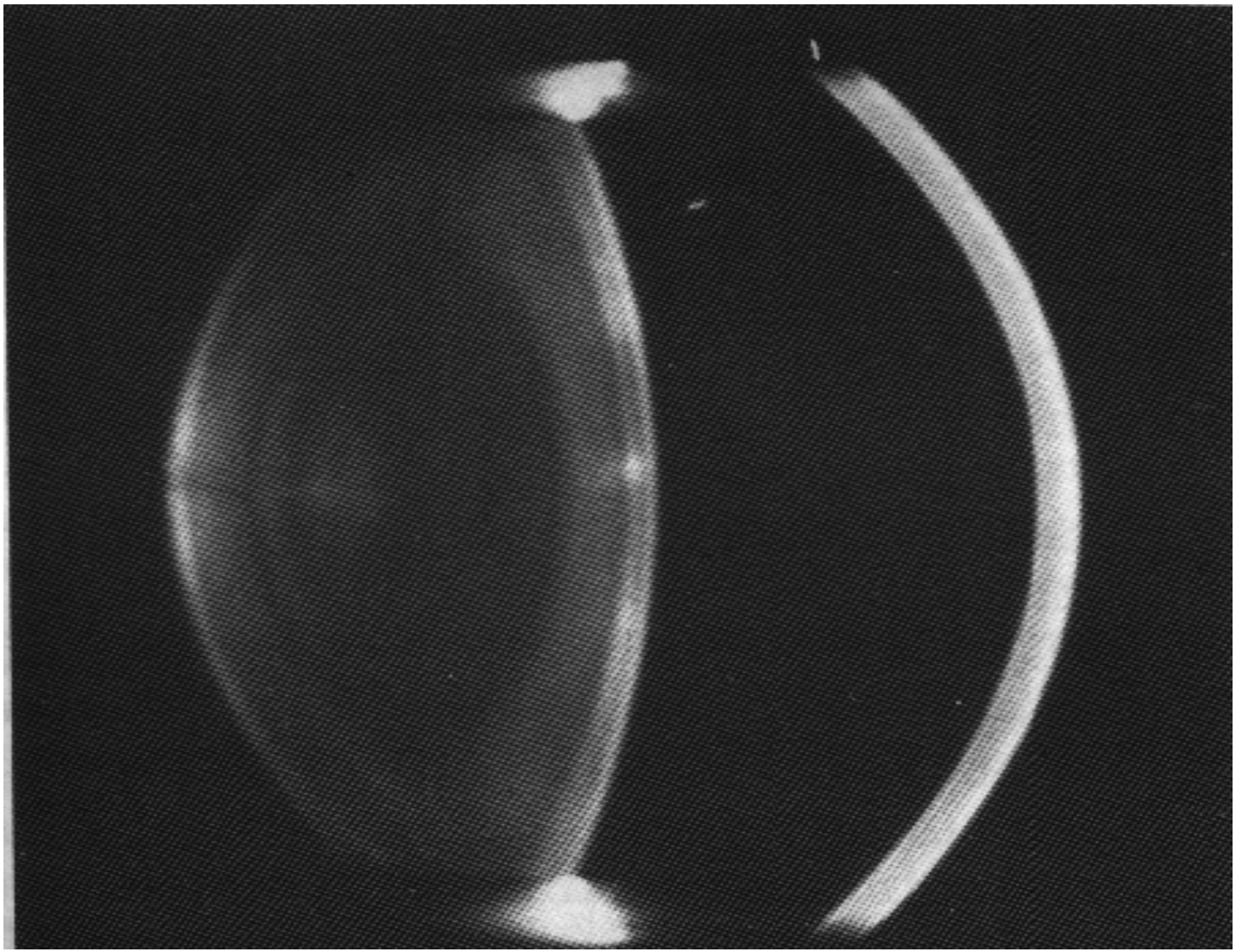


Isoindical surfaces & internal refraction



Lens Paradox: Index compensation for lens growth

The effective index of refraction is reduced by redistributing the refractive index gradient.



Reduced pupil size component of the near response reduces the spherical aberration component of blur but adds diffraction blur. **2mm is optimal**.

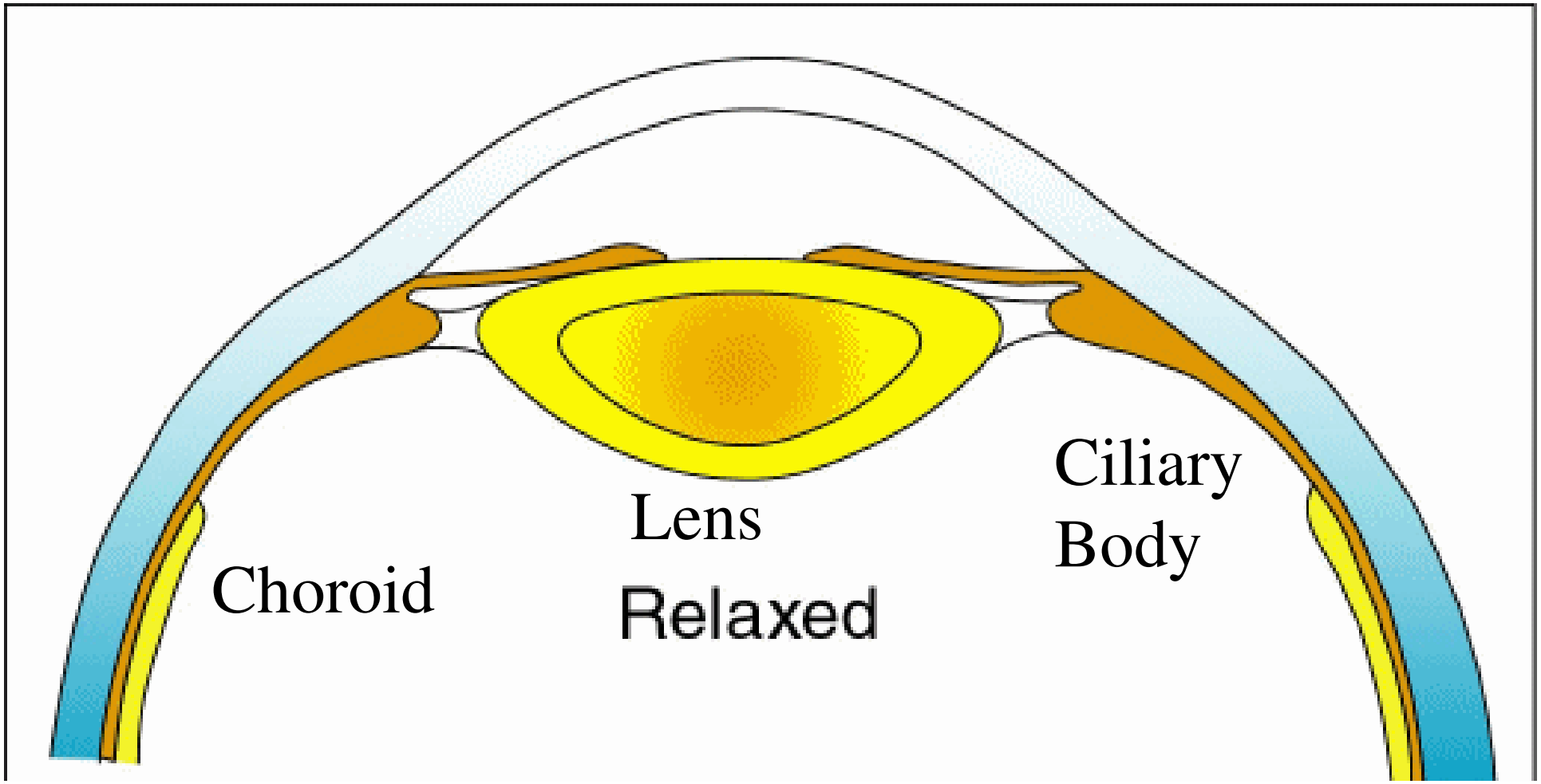
This occurs automatically with age starting in the second decade of life.

Disadvantage is reduced light level, diffraction blur and reduced field of view.

Aberrations increase the DOF.

Anatomy and Biomechnics of Accommodation

Gullstrand, Helmholtz Relaxation theory of Accommodation.

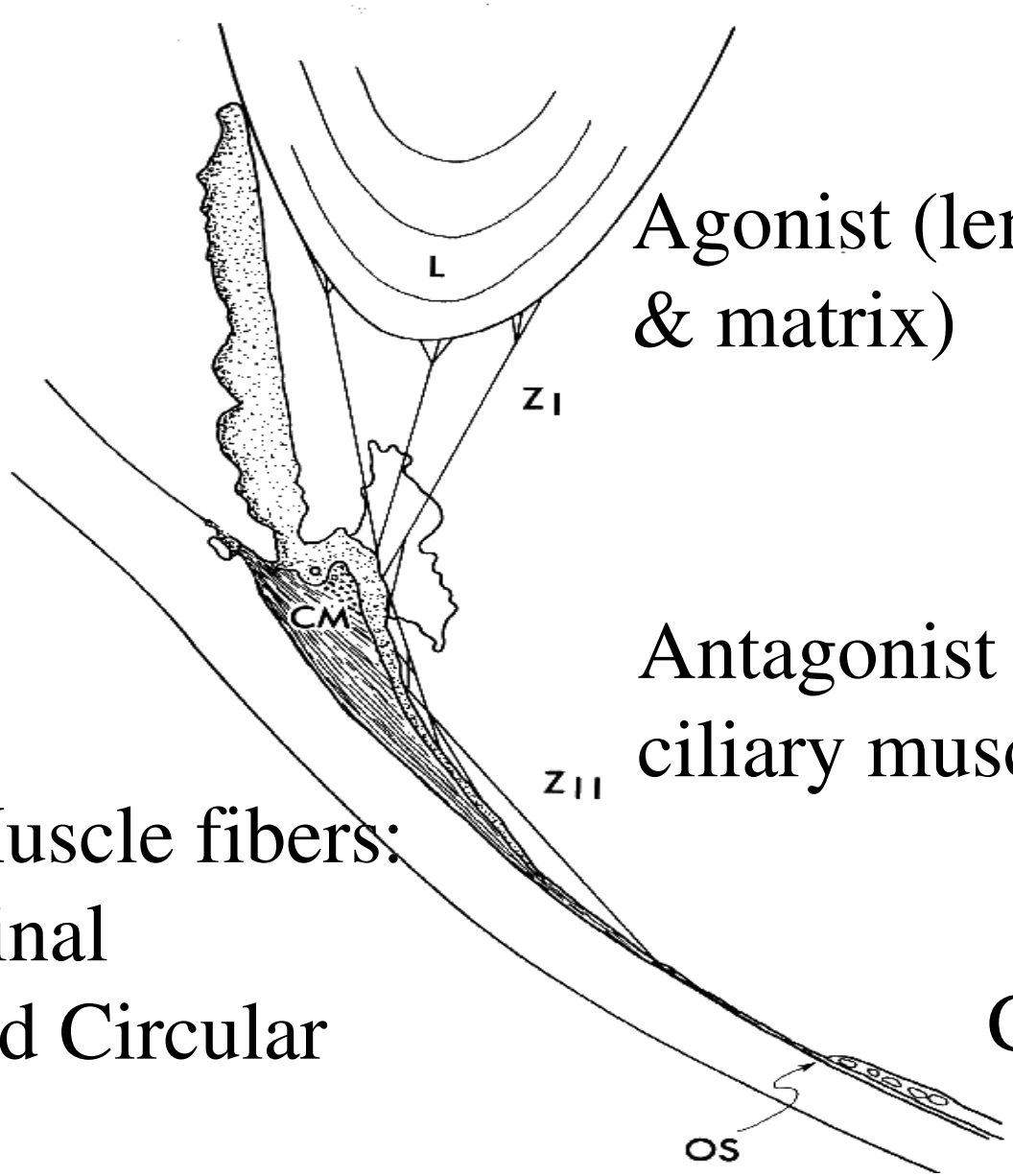


Gullstrand, Helmholtz Relaxation theory of Accommodation. Relax a stretching force on the lens capsule to allow the lens matrix to round up.

Push-pull relationship between the passive agonist lens complex and the passive antagonist (choroid & lens bag, interconnected by zonules).

Balance of force between passive components is changed by active force of the ciliary muscle.

Lenticular & Extra-Lenticular Components of Accommodation



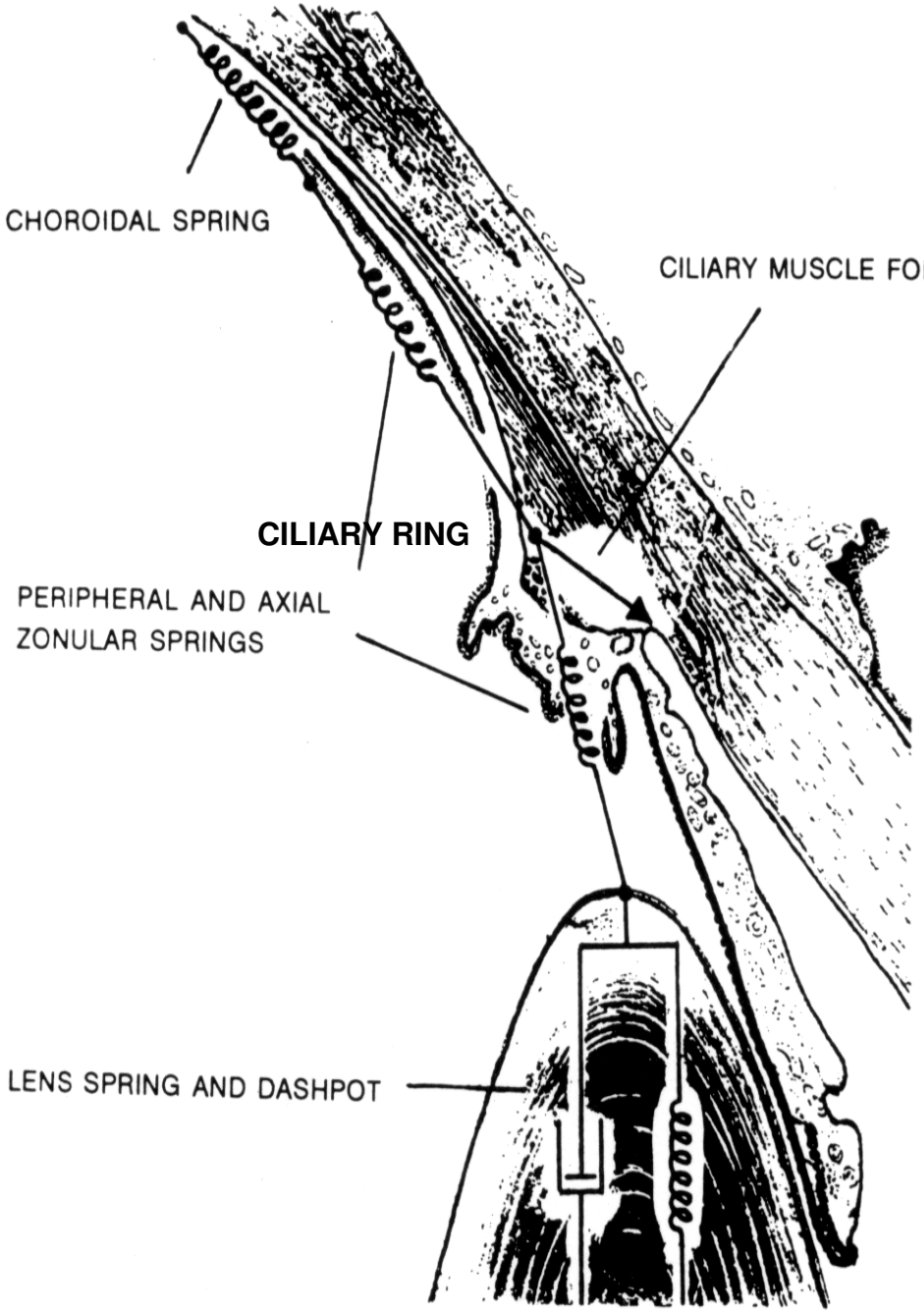
Agonist (lens capsule & matrix)

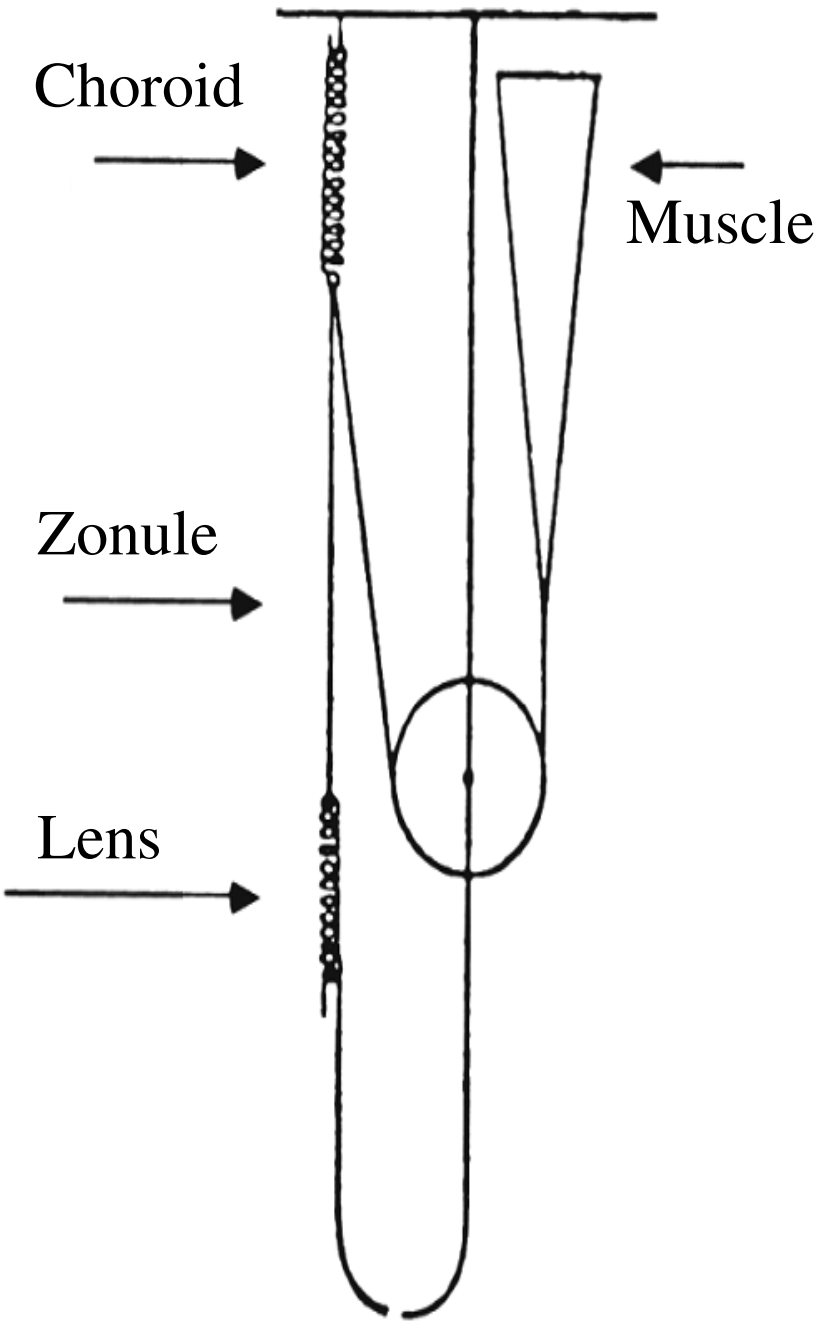
Antagonist (zonules, ciliary muscle & choroid)

Ciliary Muscle fibers:
Longitudinal
Radial and Circular

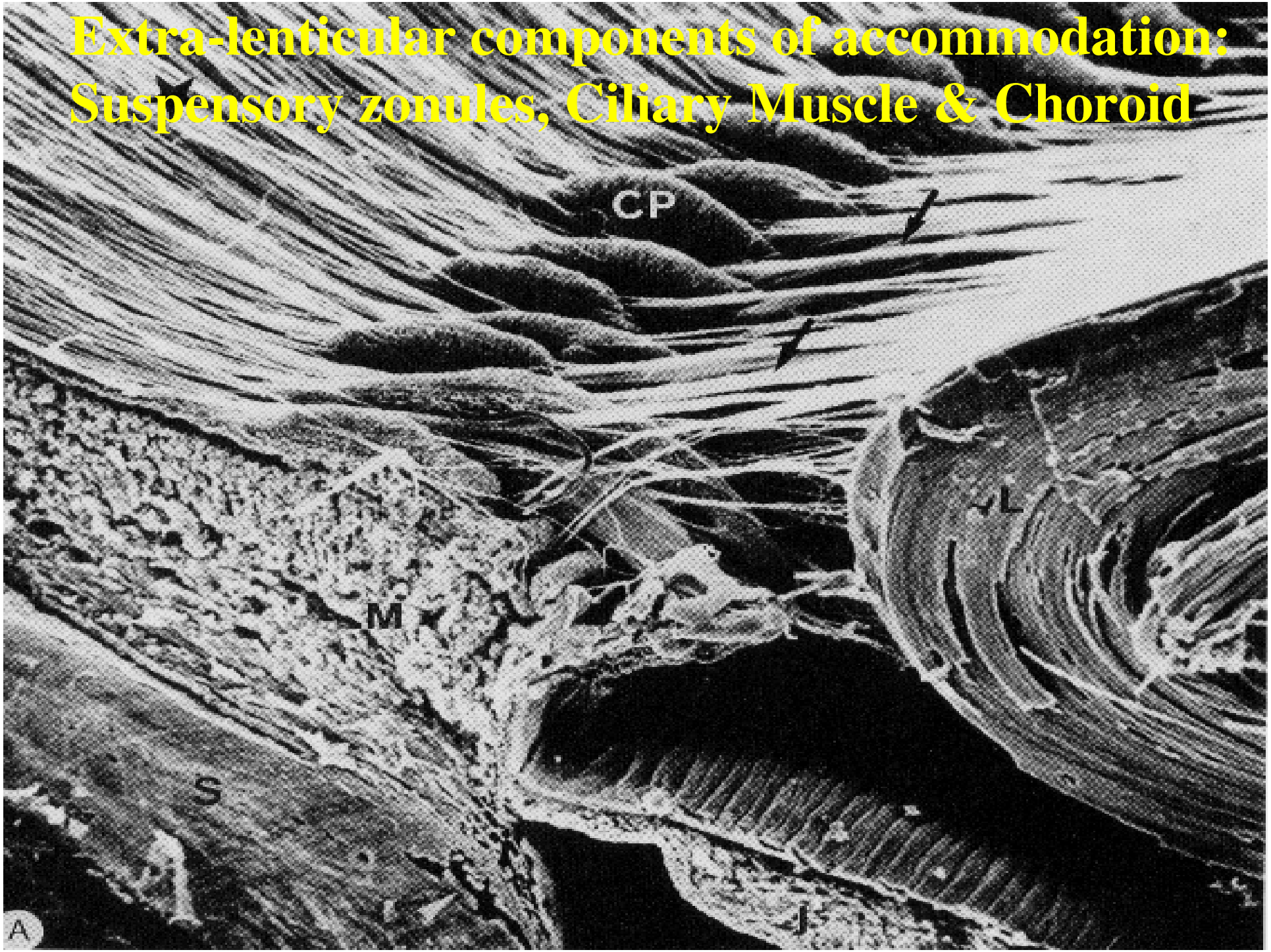
Choroid

Gullstrand biomechanics model of Accommodation

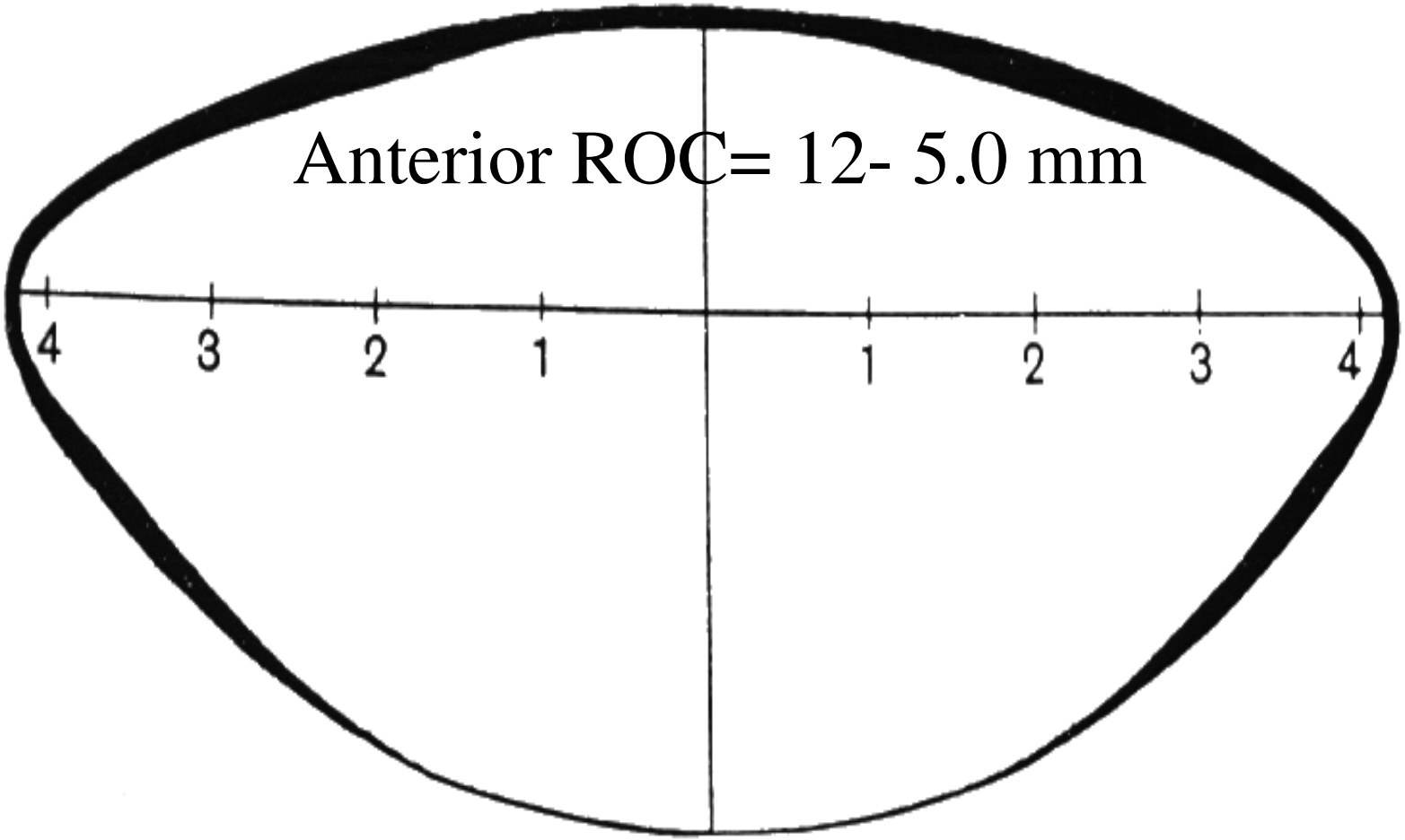




Extra-lenticular components of accommodation: Suspensory zonules, Ciliary Muscle & Choroid



Lens Capsule elasticity molds (shapes) the lens matrix

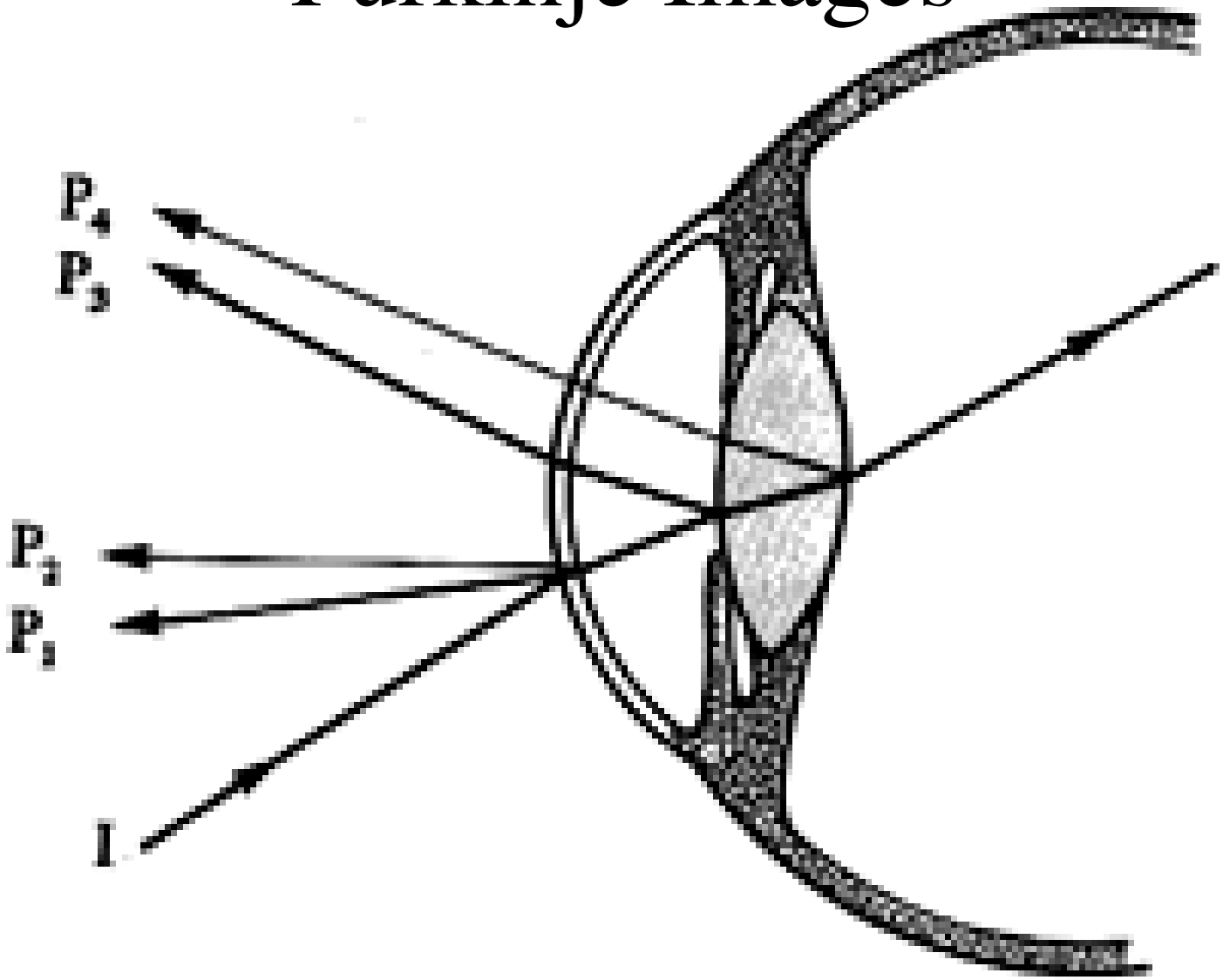


Passive agonist that shapes the lens
during ciliary muscle contraction:
Internal (viscous) and external (elastic) factors

Changes in the lens curvature during accommodation

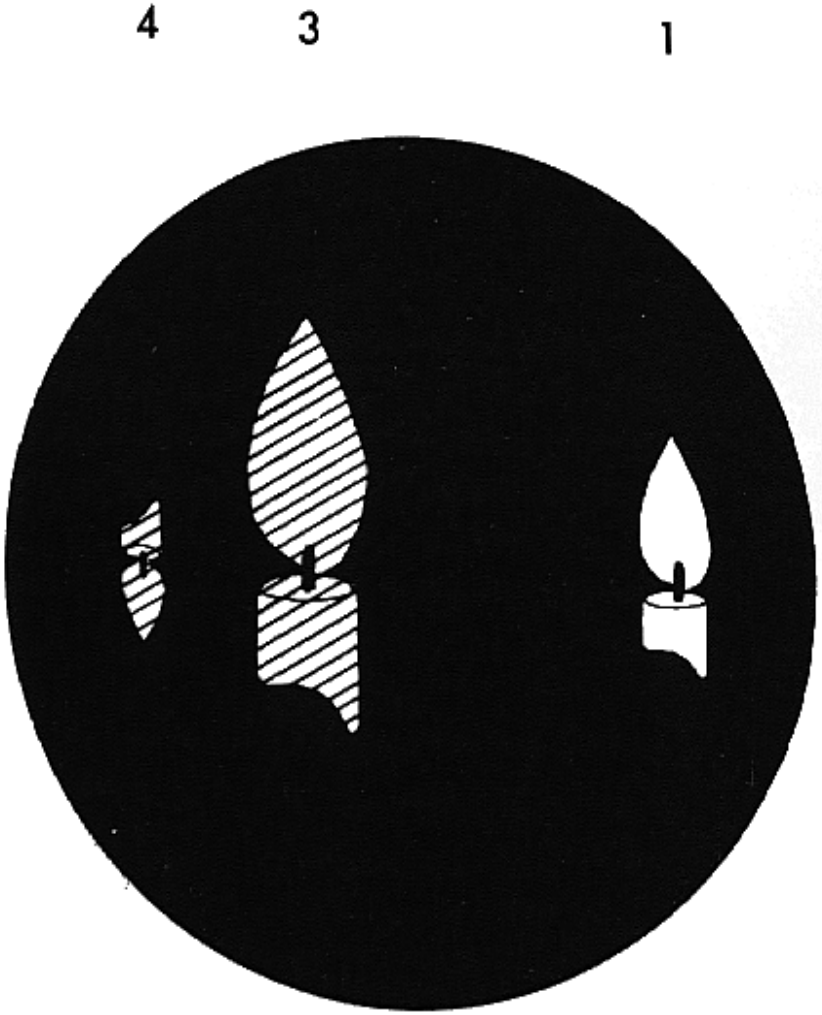
How to measure accommodation objectively

Purkinje Images



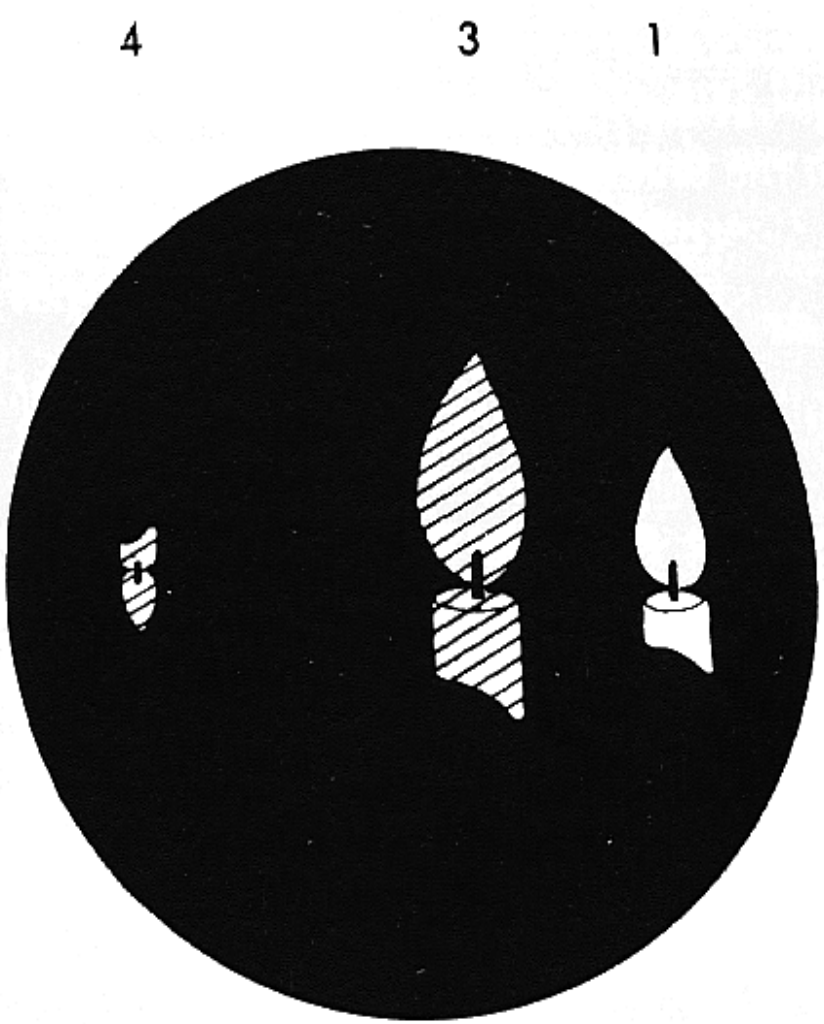
Catoptric images are reflected from optical surfaces

Relaxed



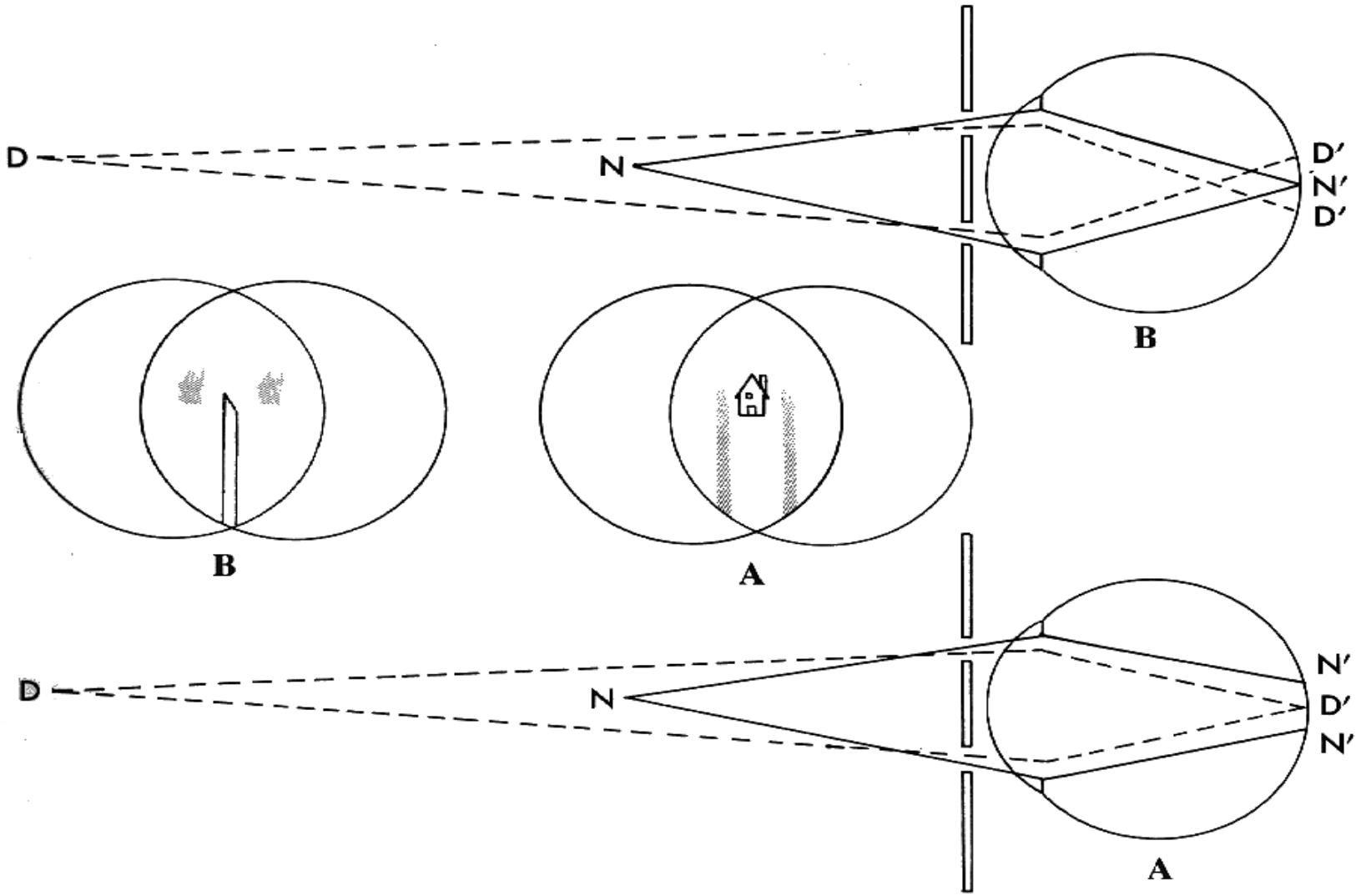
A

Accommodated

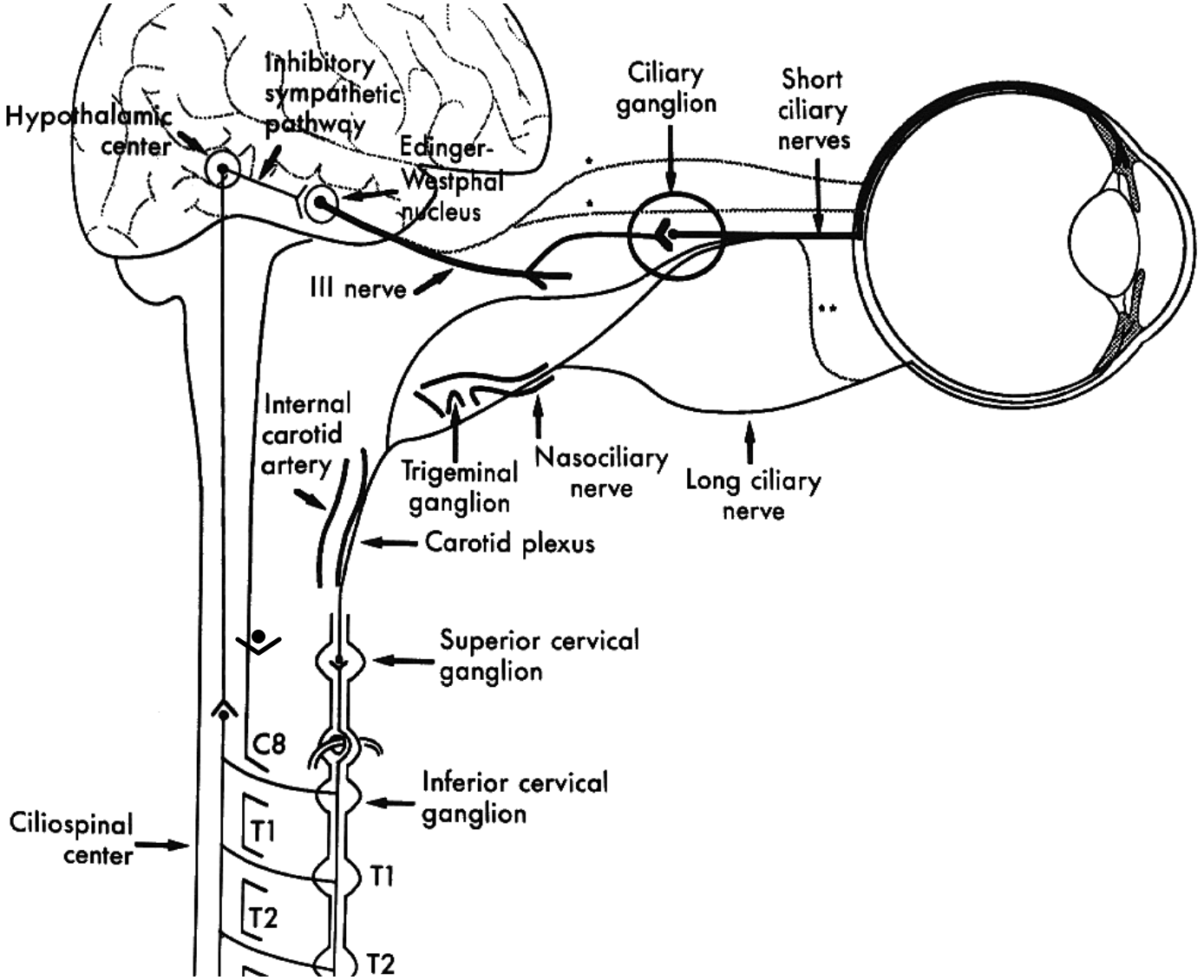


B

Scheiner double pupil



Two branches of the autonomic NS
Sympathetic and Parasympathetic pathways



5 minute break

Presbyopia: the reduction of accommodation amplitude with age.

Compensation:

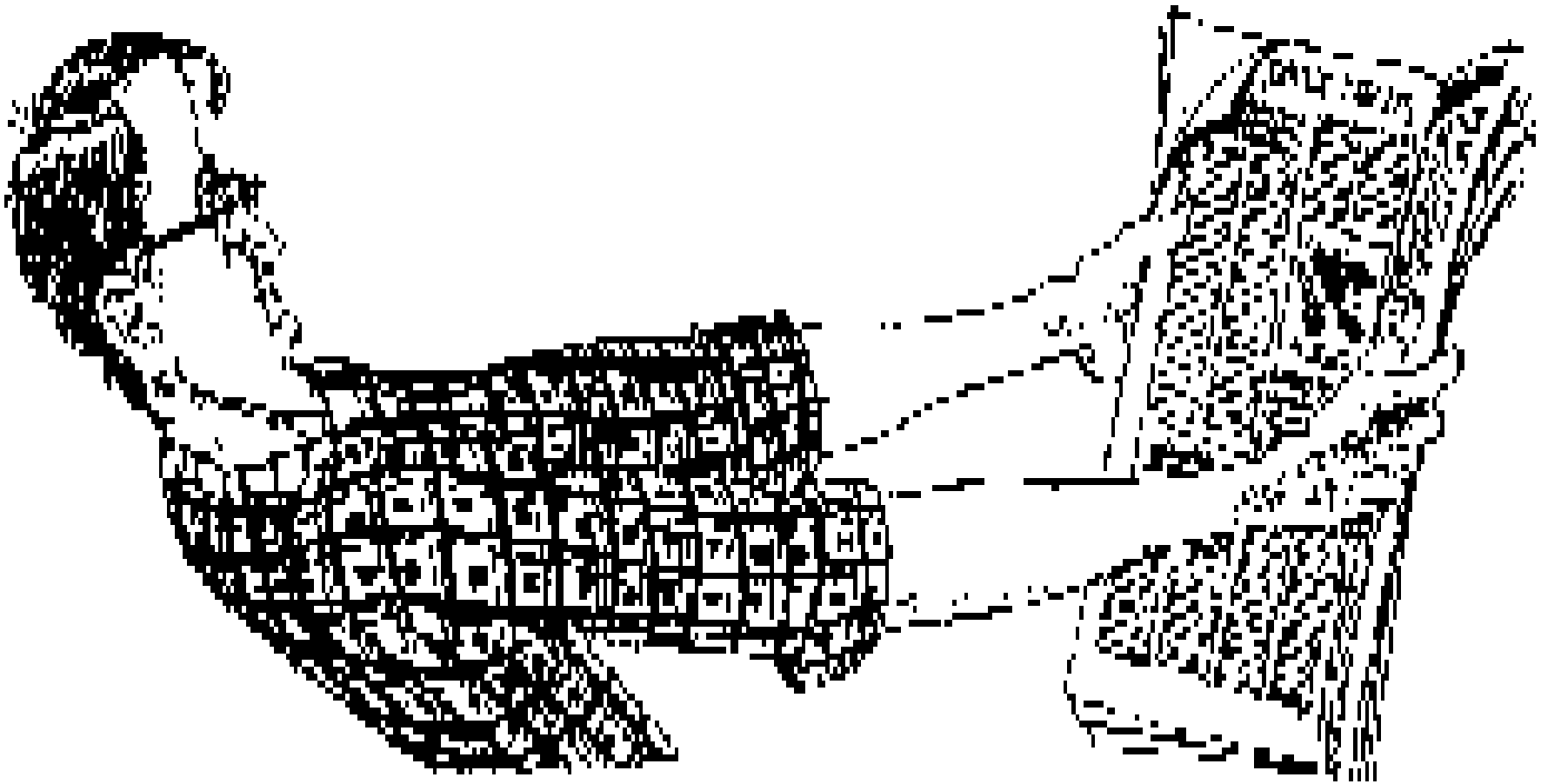
Adjust viewing distance

Constrict pupil and increase aberrations
increase the **D**epth **O**f **F**ocus

Optical aids- bifocals, monovision,
& simultaneous vision (increase aberrations)

Accommodating intraocular lens implant (AIOL)

Adjust the Object (viewing) Distance



The Problem: PRESBYOPIA
After age 52 the eye no longer accommodates

Absolute Presbyopia: Age 52

The near point equals the far point.

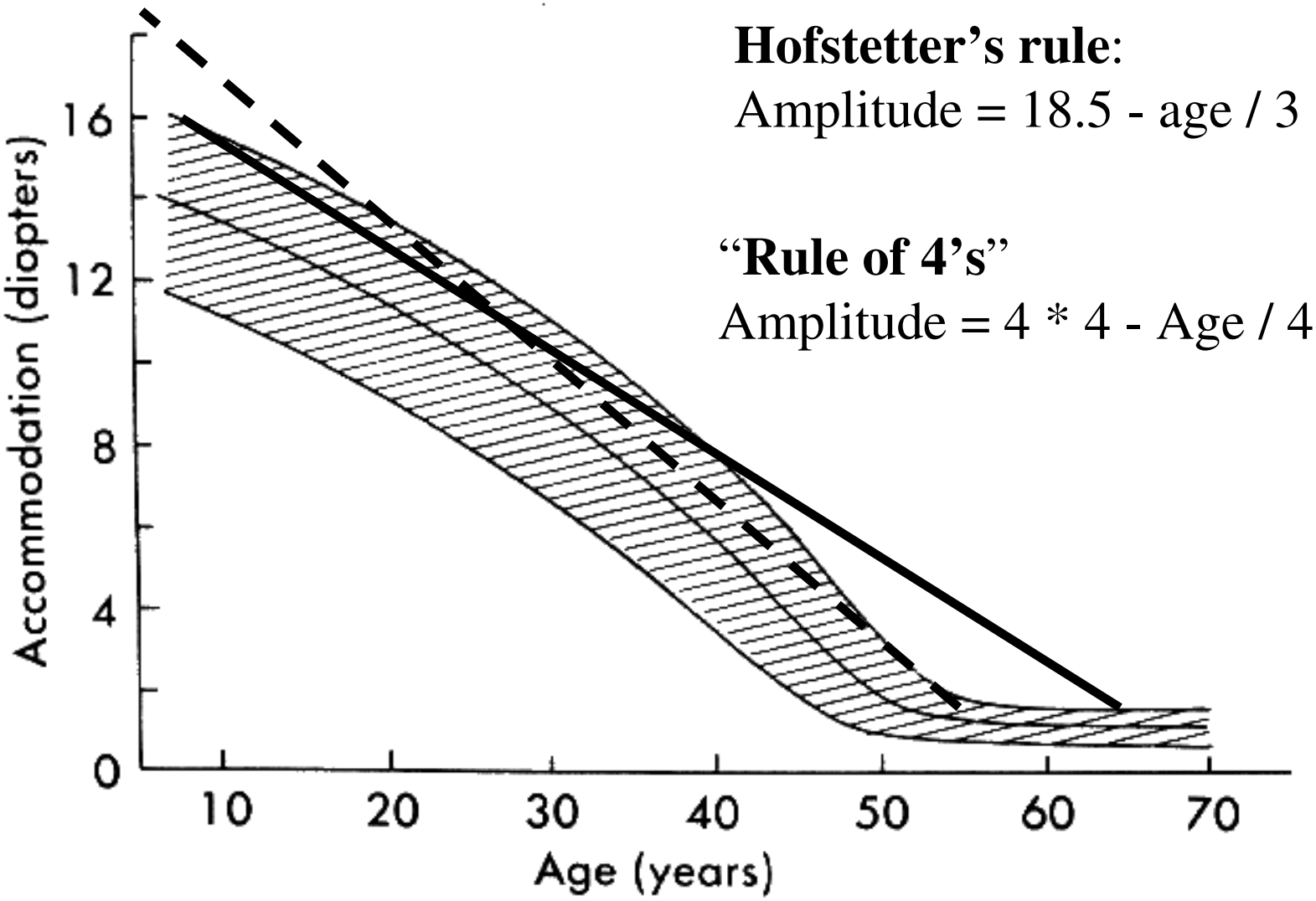
Amplitude of accommodation equals zero.

Functional Presbyopia:

The near point recedes out beyond the near working distance.

The near working distance requires more than the full amplitude of accommodation.

Time course of Presbyopia



Hofstetter's rule:
Amplitude = 18.5 - age / 3

"**Rule of 4's**"
Amplitude = 4 * 4 - Age / 4

Amp = 18.5 – (Age/3)

rearrange
Age = 3 x (18.5 - Amp)

Age for amplitude of 2.5D

Age = 3 x (18.5 – 2.5) = 3 x (16) = 48 years

What Causes Presbyopia.

It's a combination of the way we accommodate and the way the lens grows.

Presbyopia is accelerated by the same factors that cause cataract. UV radiation & diet have an influence. People living near the equator have earlier onset of presbyopia.

Ocular changes that contribute to Presbyopia:

Statics:

-Lens rounds with age & increases minimum curve

-Cortex of the lens becomes less malleable-

More layers cause pressure bandage **friction effec**

-Capsule is **stiffer** (less compliance)

-Choroid is stiffer (less compliant)

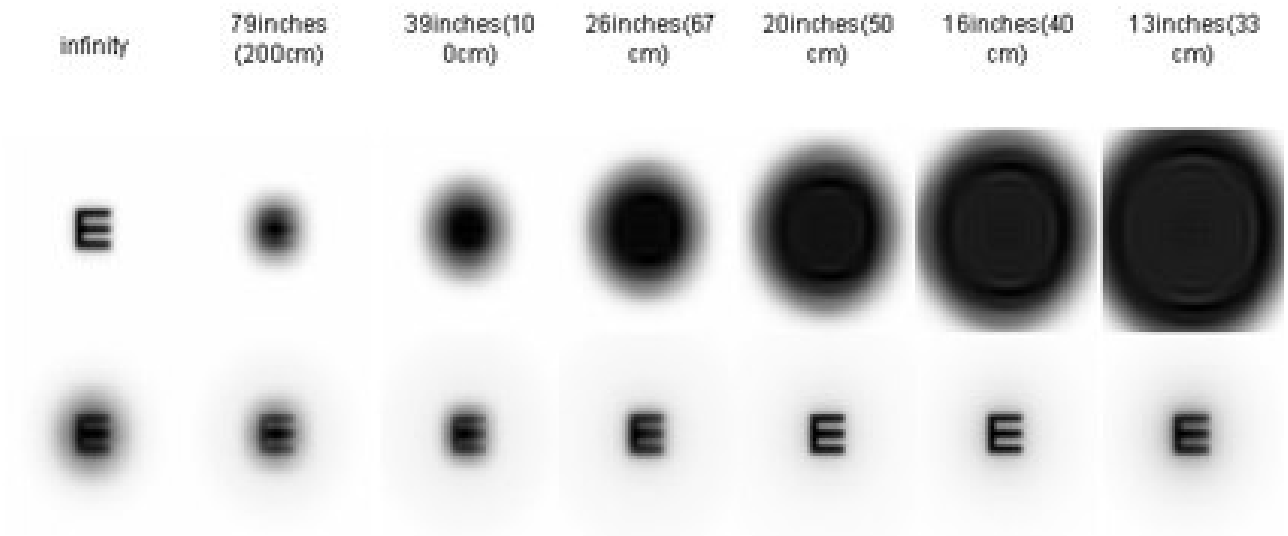
Consequence:

Reduced amplitude of accommodation from rounding, and greater elastic opposition force applied by the stiffer choroid.

Dynamics:

-Lens becomes more viscous- More sluggish

Consequence: Static & dynamic changes require more force from the ciliary muscle to change accommodation quickly.



A letter E as seen with out any correction (top line), and with the addition of negative spherical aberration (bottom line). *G. Yoon, University of Rochester*

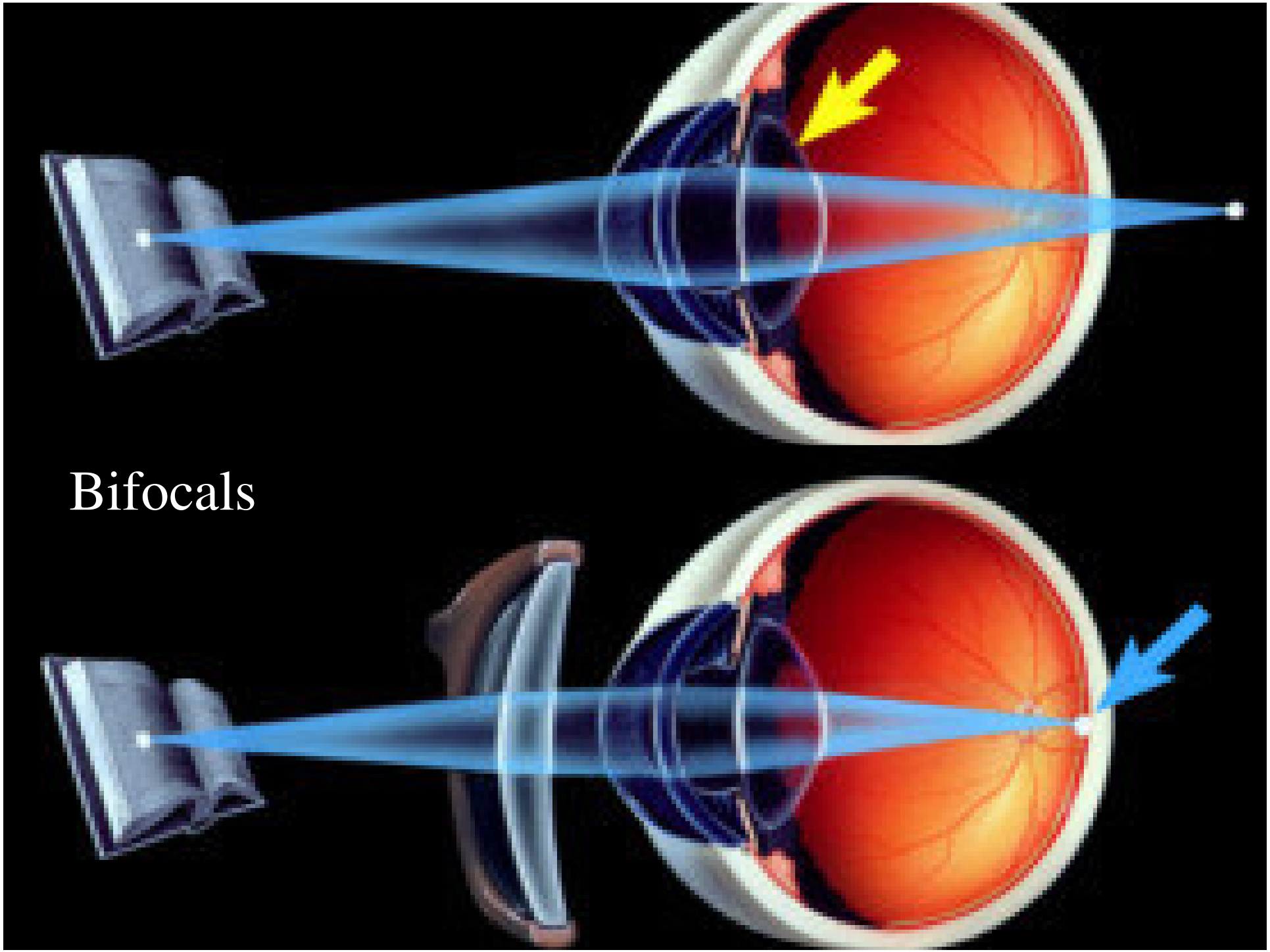
Treatment options:

Optical aids

- Reduce pupil size (occurs naturally)
- Bifocal spectacles
  - fixed and progressive
- Contact lens bifocals
- Simultaneous vision contact lenses
- Monovision contact lenses

Surgical Correction

- Accommodating IOL
- IOL (intraocular lens implant)
  - Malleable and Preformed


Bifocals

Which of these aspects of presbyopia can be changed to restore accommodation?

Lens position- translate toward the cornea
Lens matrix viscosity and compliance

Lens matrix implants for treatment of Presbyopia:

http://www.refractivesource.com/patients/emerging/procedures_for_presbyopia.htm

http://schorlab.berkeley.edu/

click A-IOL model

Accommodating Intraocular Lenses Inserted into the Lens Bag (Capsule)

Malleable Polymer- Catarex

A problem is that it becomes opaque

Preformed Polymer- C&C Vision (AT-45)

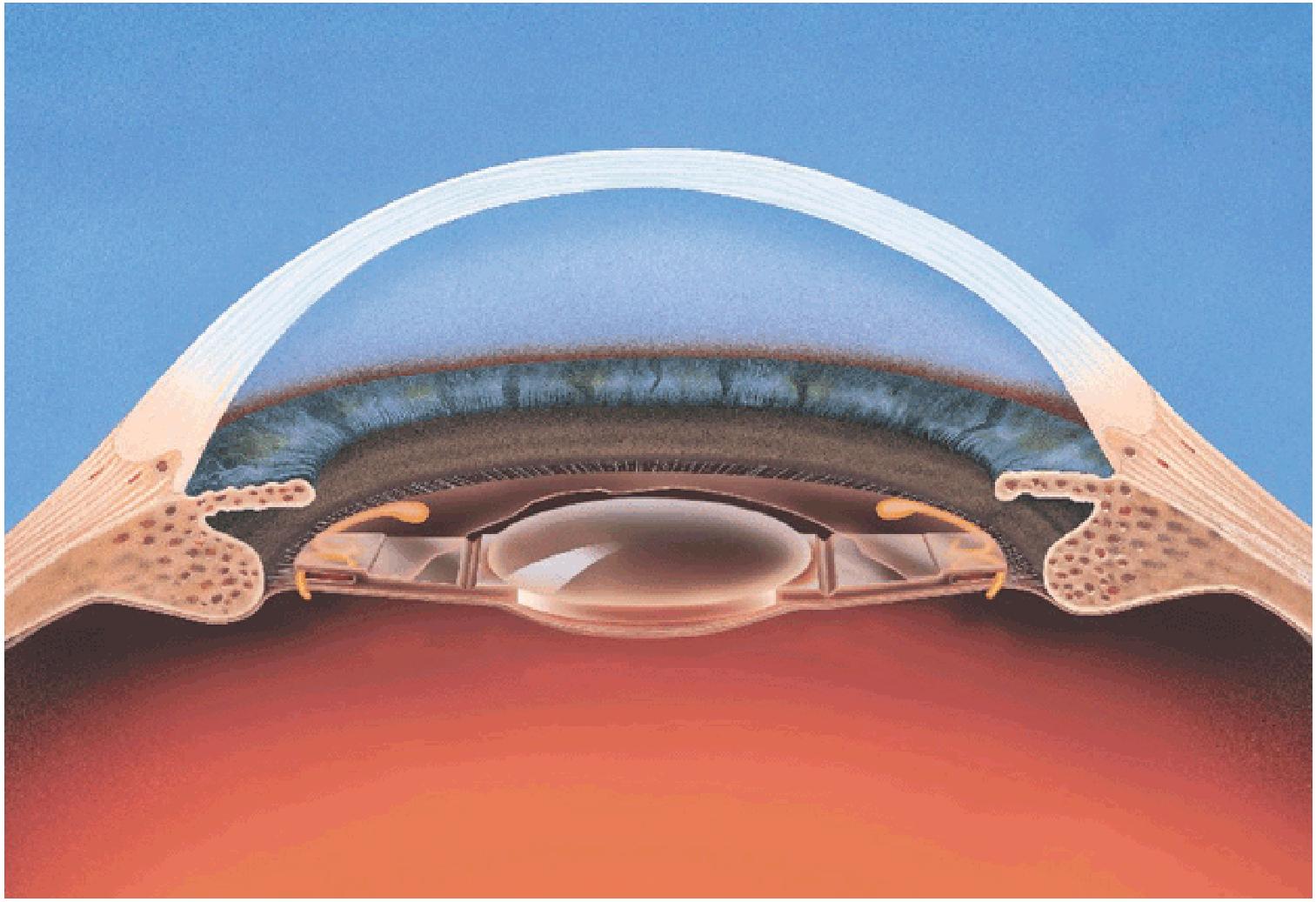
Human Optics AG

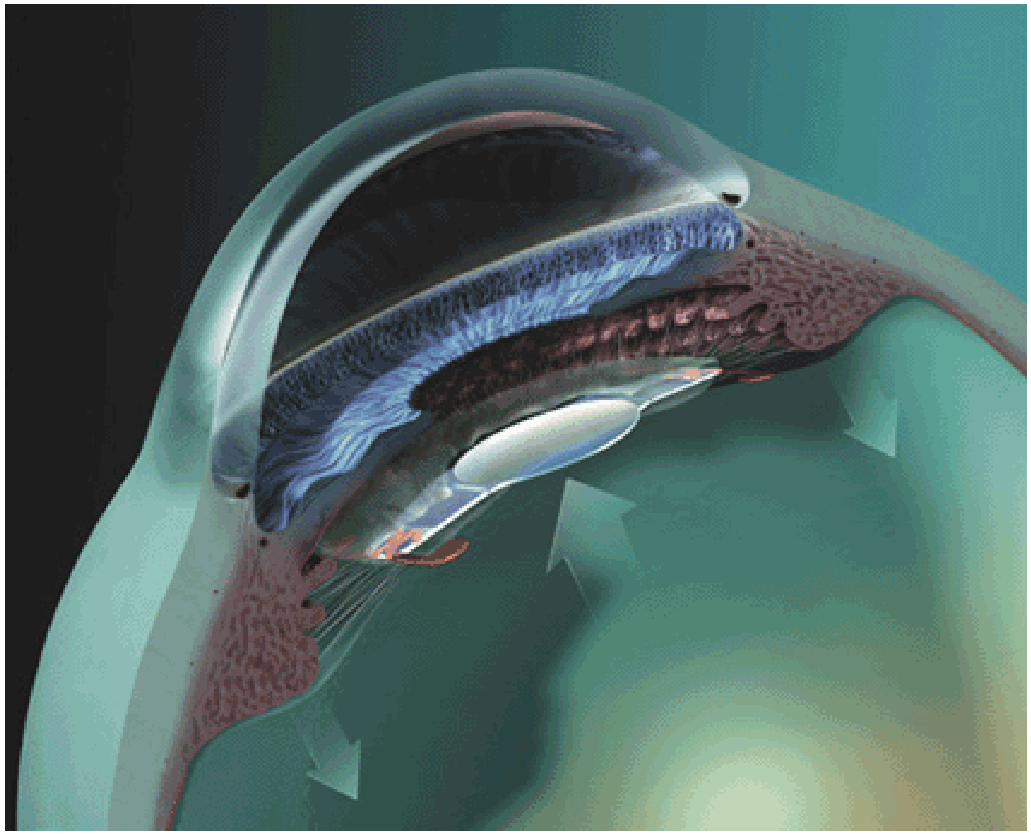
Visiogen (Galelian Telescope)

B&L Safarazi technique

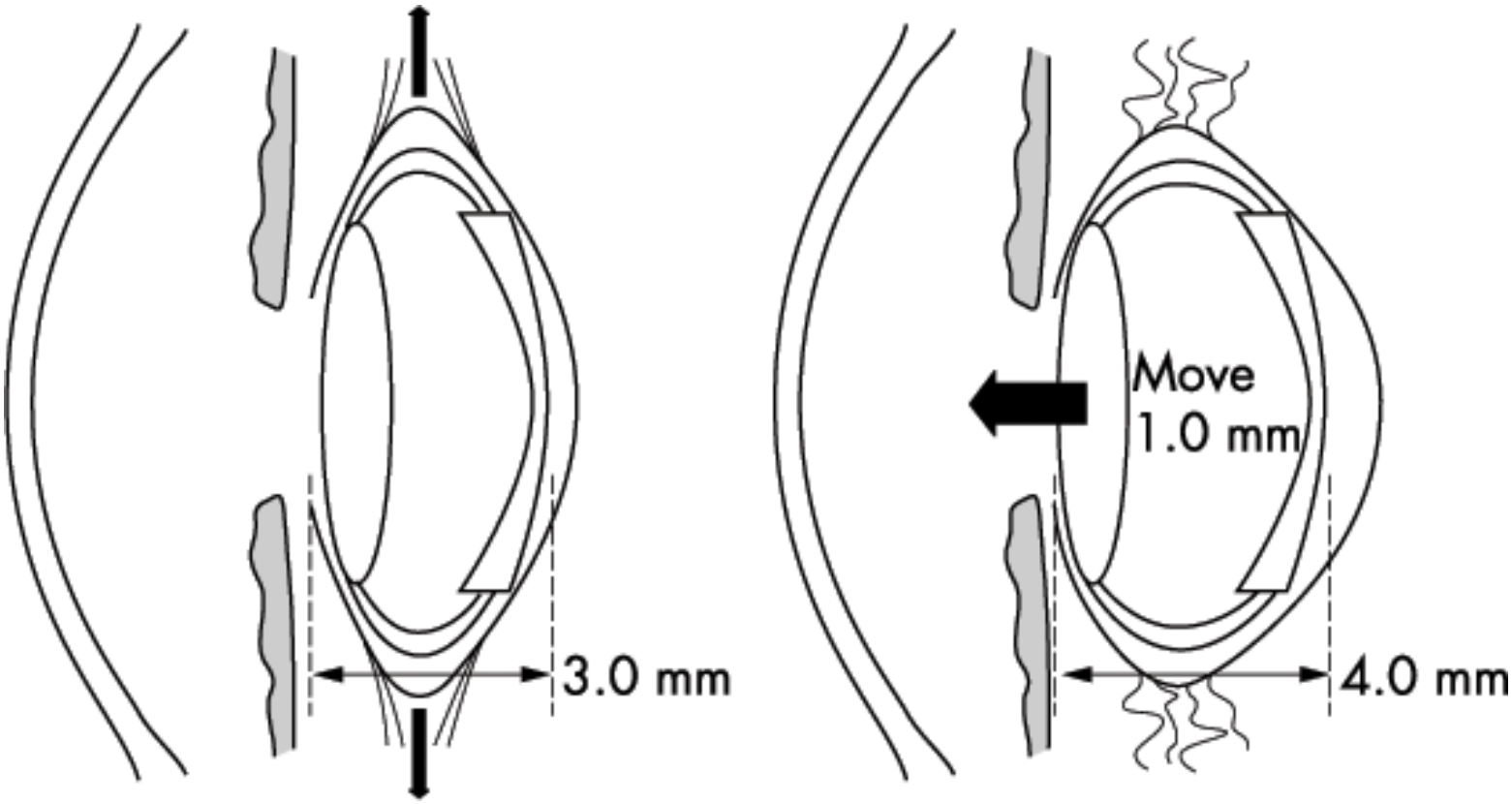
Limited amplitude of accommodation (1-2D)

Role of increased aberrations due to lens tilt is unclear.



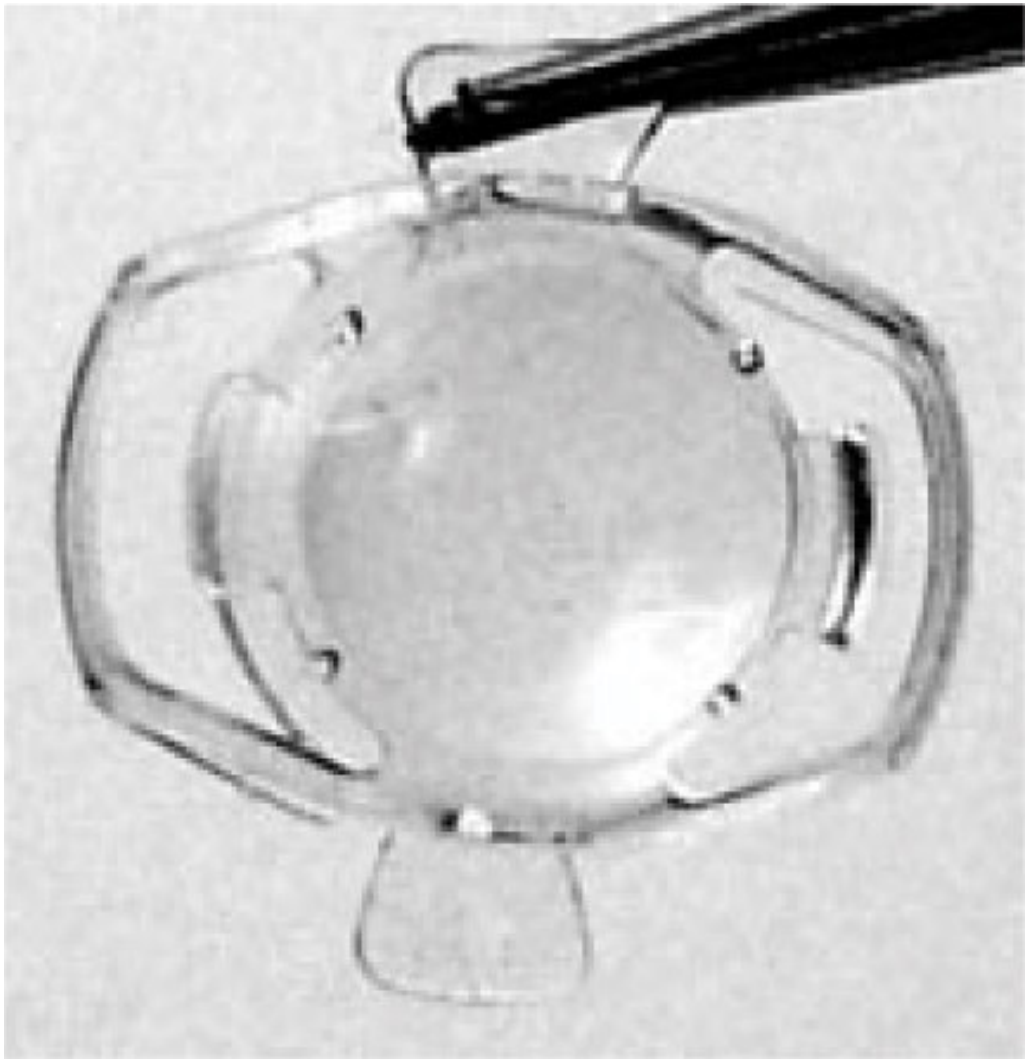


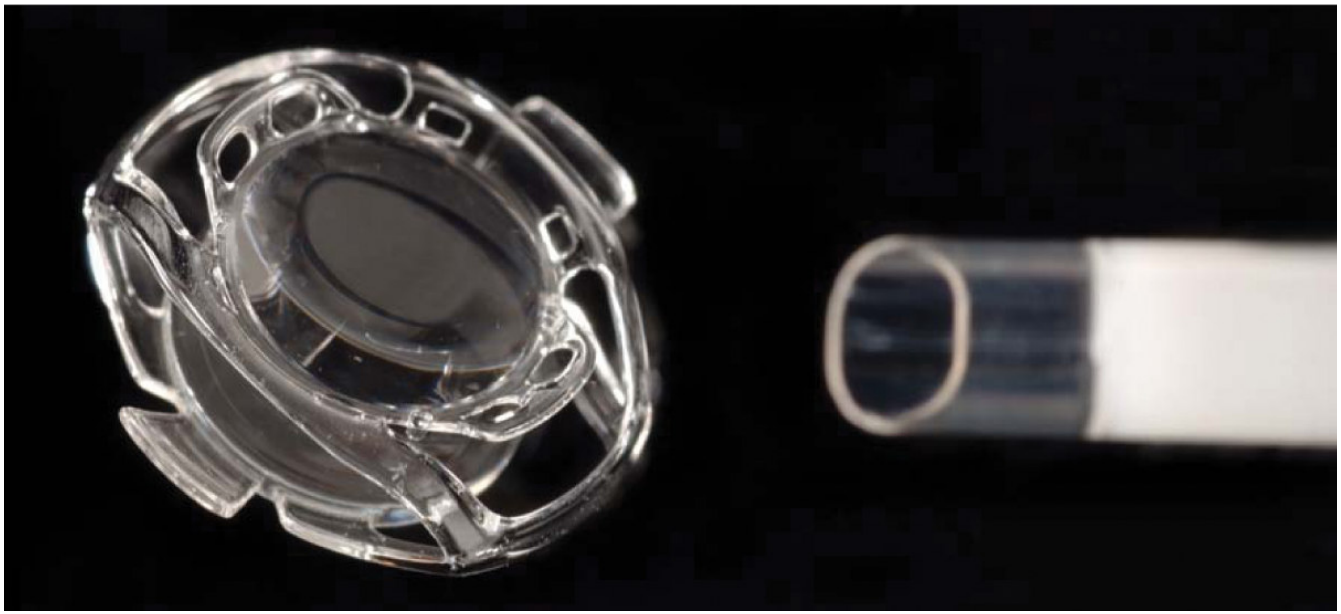
Accommodating IOL (+ 30D Galilean telescope)



1.5 mm produces up to 3D accommodation

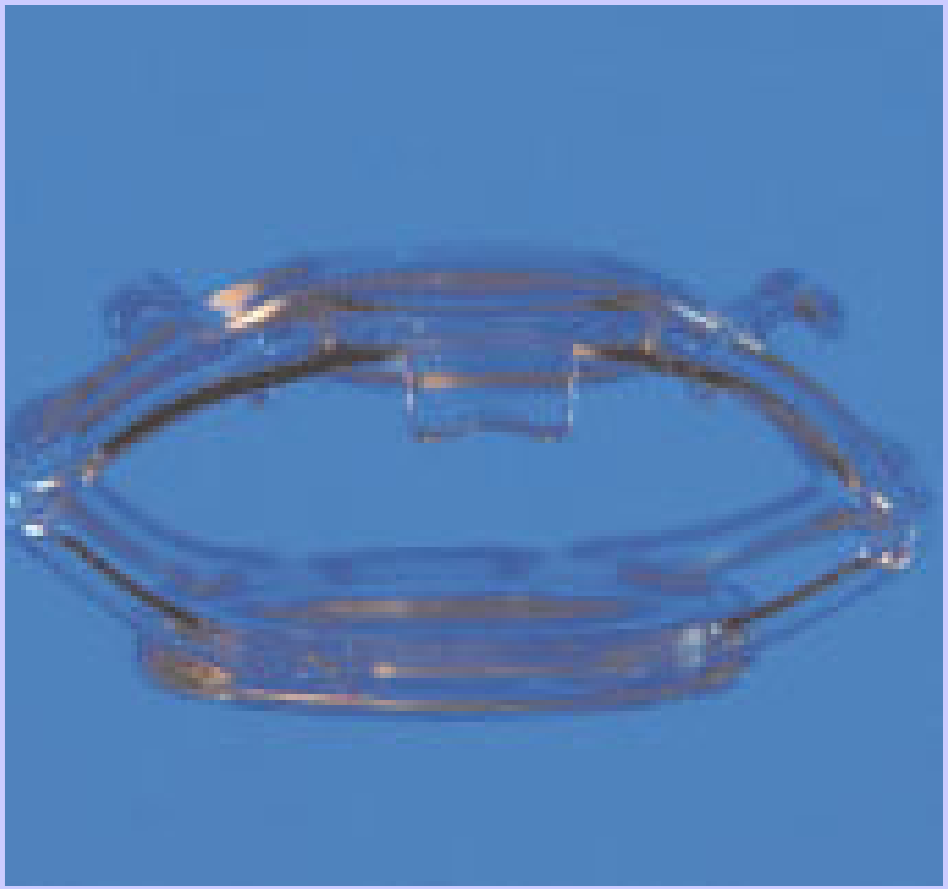
Haptics support Visiogen translating “Synchrony” + 30D IOL Galilean telescope





Visiogen

Haptics support Visiogen translating IOL telescope



http://www.crstoday.com/02_current/18.html
http://eyeworld.org/jan04/0104p12.html

Lunch Time