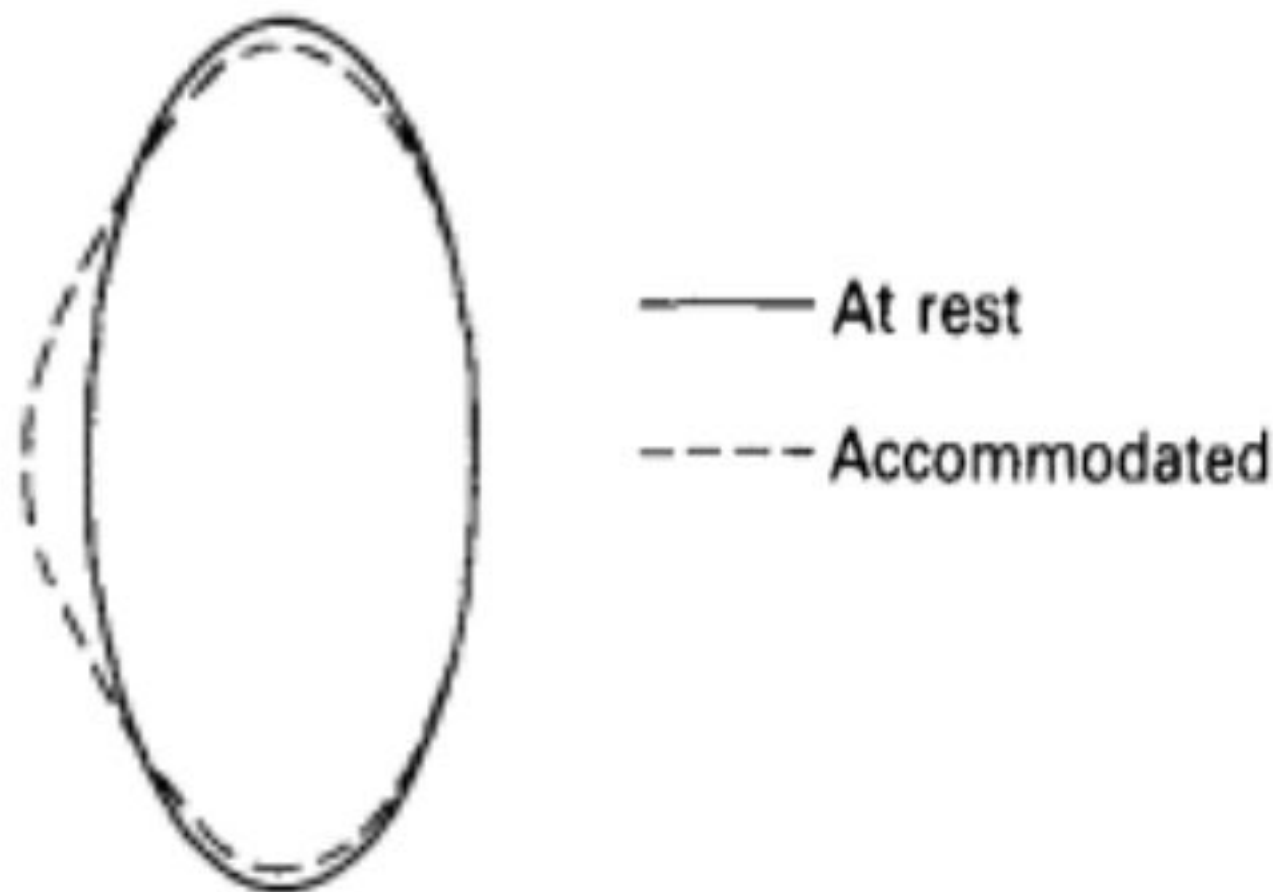


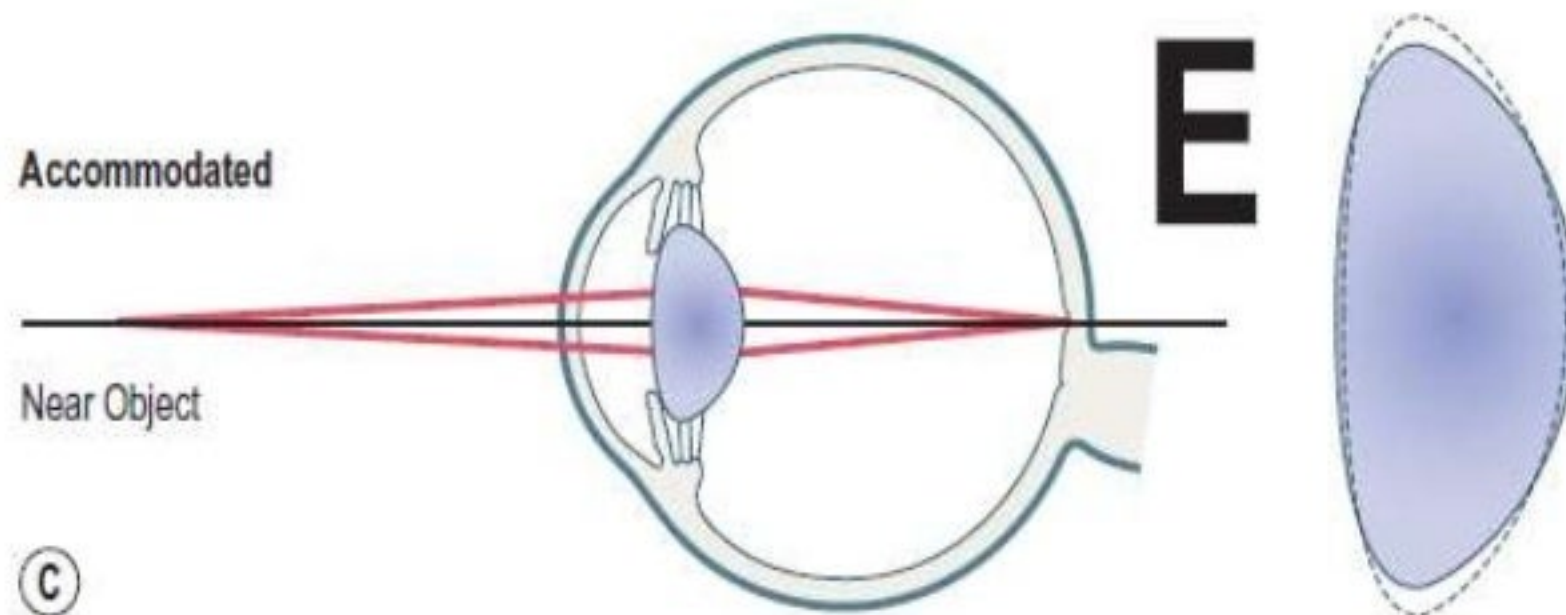
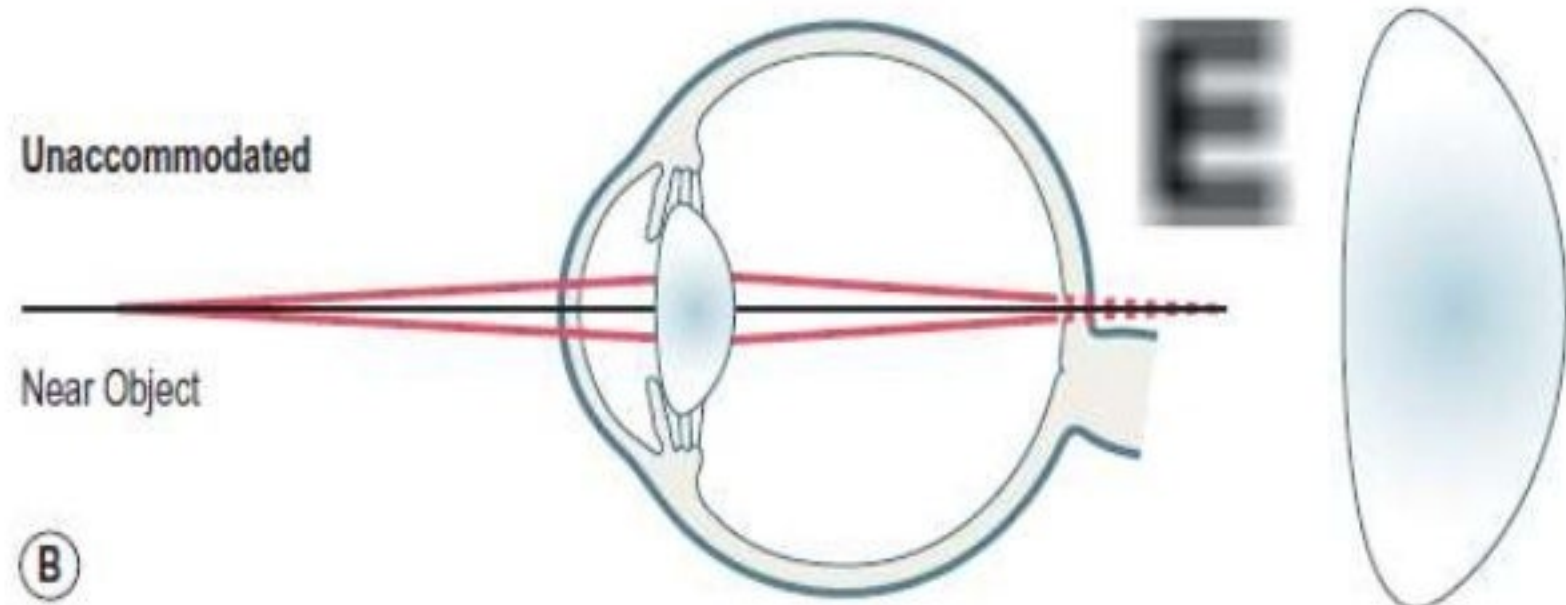
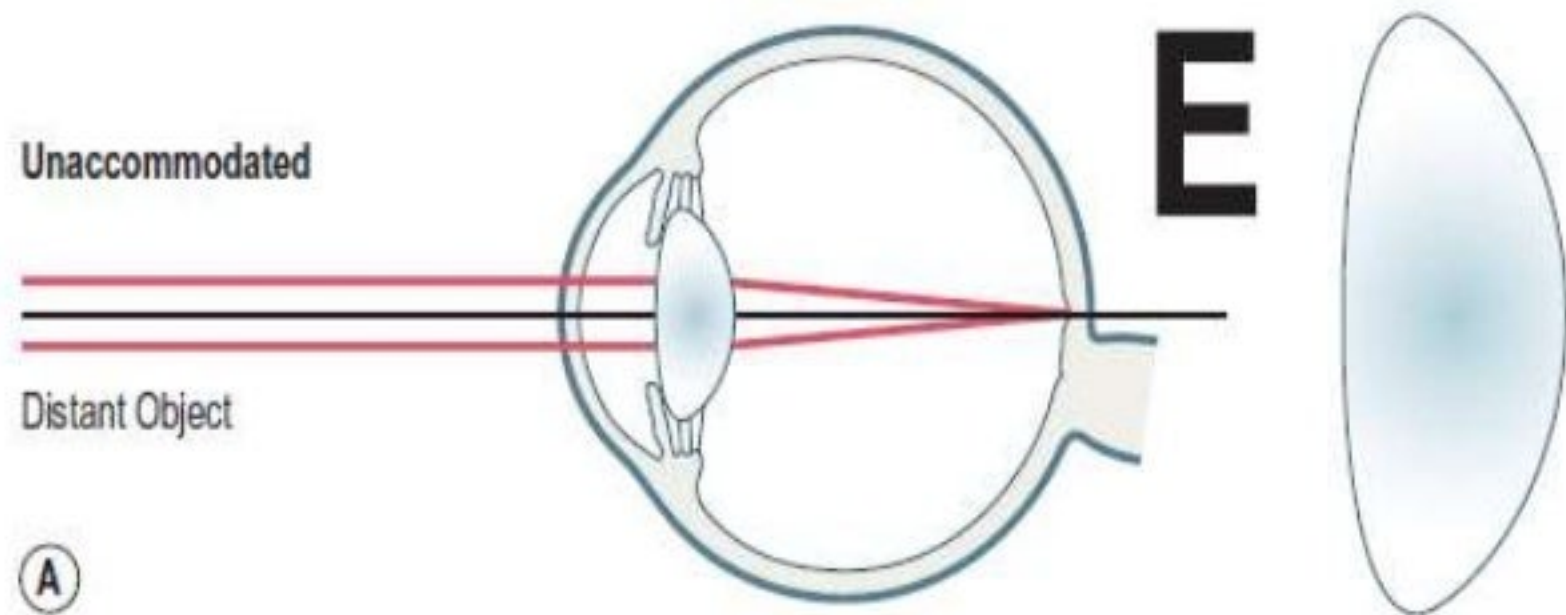
# Accommodation and its anomalies

vidya

# Definition

Accommodation is the mechanism by which the eye changes refractive power by altering the shape of lens in order to focus objects at variable distances





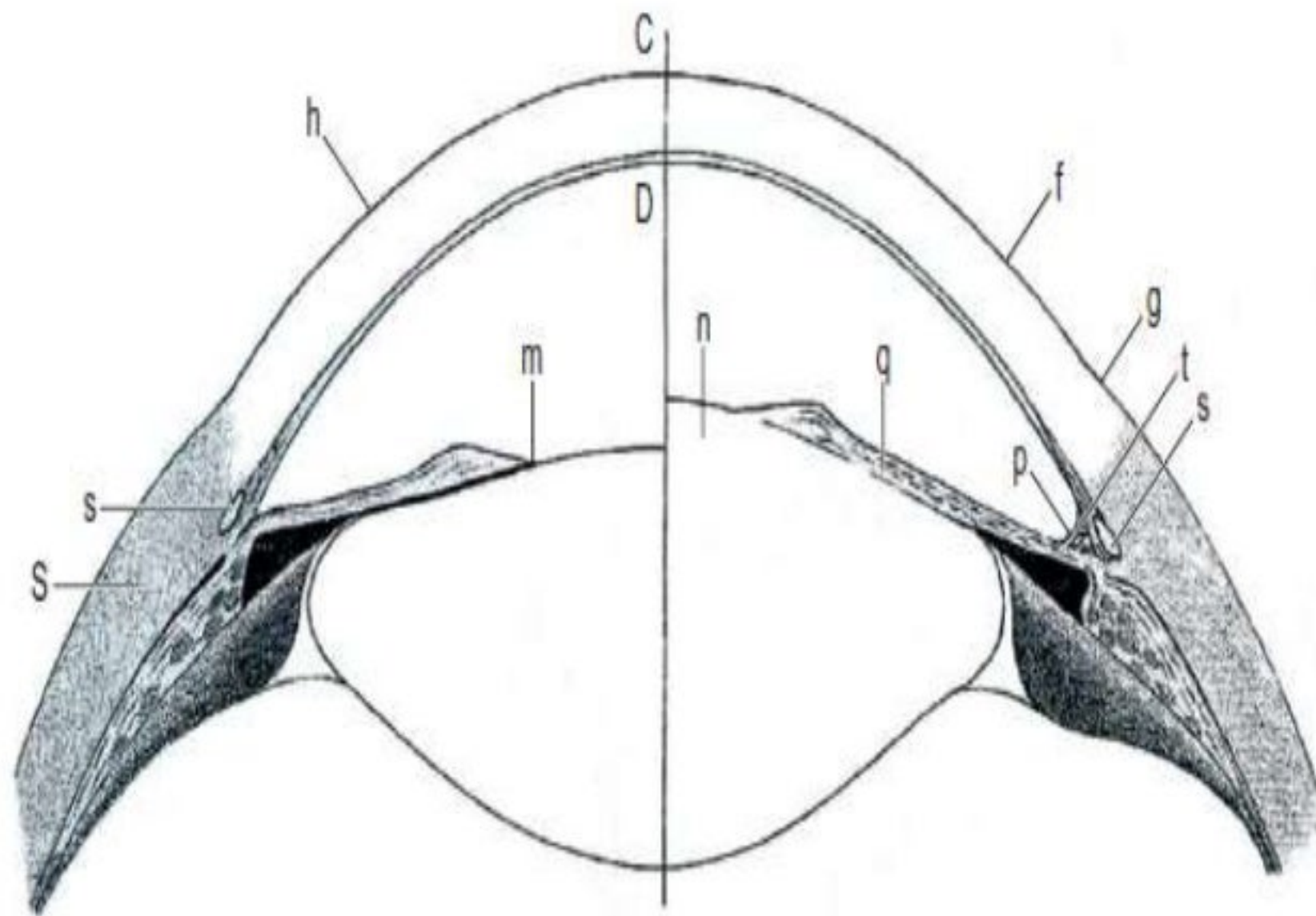
**Figure 3.3** The accommodative optical changes in the eye occur through an increase in optical power of the crystalline lens. **(A)** The unaccommodated emmetropic eye is focused on a distant object with the lens in an unaccommodated state. **(B)** A near object subtends divergent rays and in the unaccommodated eye the image would be formed behind the retina and is therefore out of focus when the lens remains unaccommodated. **(C)** In the accommodated eye, the in focus image of the near object is formed on the retina when the lens is in an accommodated state.

# Theories of Accommodation



## Theories of mechanism of accommodation

- The exact mechanism of accommodation is not known but the Principal fact is that ACCOMMODATION is a feature of increase in the curvature of the lens which affects anterior surface mainly.
- **Relaxation theory of HELMHOLTZ “Capsular Theory”:**
- He considered that lens was elastic and in normal state it is stretched and flattened by tension of the suspensory ligaments.
- During accommodation, contraction of ciliary muscle shortens ciliary ring and moves towards the equator of the lens.
- Relax the suspensory ligaments, relieving strain.
- Lens assumes more spherical form, increasing thickness and decreasing diameter.



**Figure 3.1** Diagram showing the mechanism of accommodation of the human eye as described by Helmholtz. The left half depicts the eye in the unaccommodated state and the right half depicts the eye in the accommodative state. Helmholtz described an increase in lens thickness, an increase in the anterior surface curvature, an anterior movement of the anterior lens surface, but no posterior movement of the posterior lens surface. Key: S, sclera; s, Schlemm's canal; h, cornea; F, side for far vision; m, unaccommodated lens; n, accommodated lens; q, iris; p, trabecular meshwork; f, clear cornea; g, limbus; N, side for near vision; C-D, optical axis). (From Helmholtz von HH. Helmholtz's Treatise on Physiological Optics. Translation edited by Southall JPC in 1924 (original German in 1909). New York: Dover, 1962: vol. 1, ch. 12.)



**A**

Ciliary muscle

Zonules



Unaccommodated  
lens

**B**

Ciliary muscle  
contracts

All zonules  
relax and curl

Tension in  
lens causes it  
to become  
rounder



Accommodated lens  
Helmholtz theory

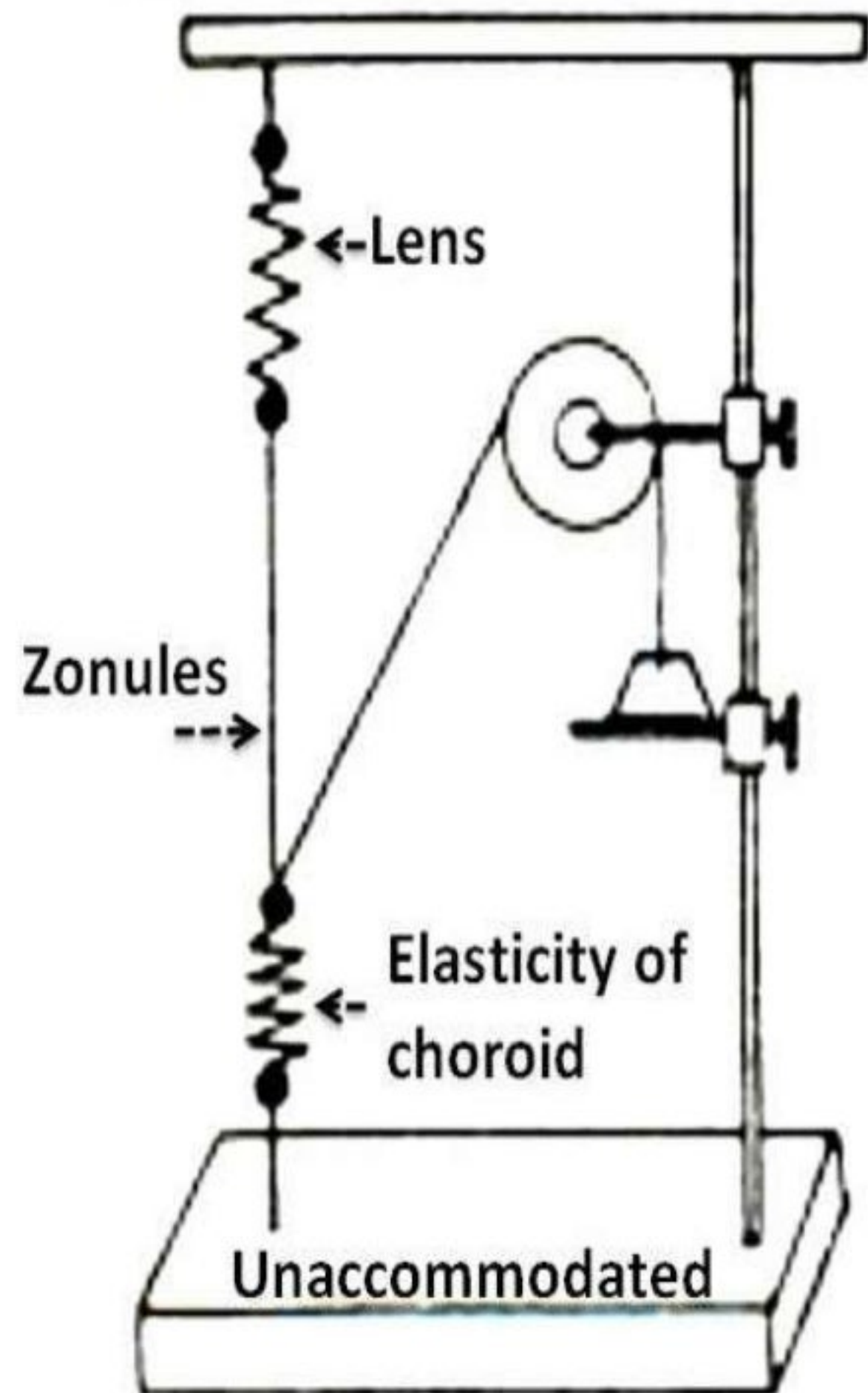
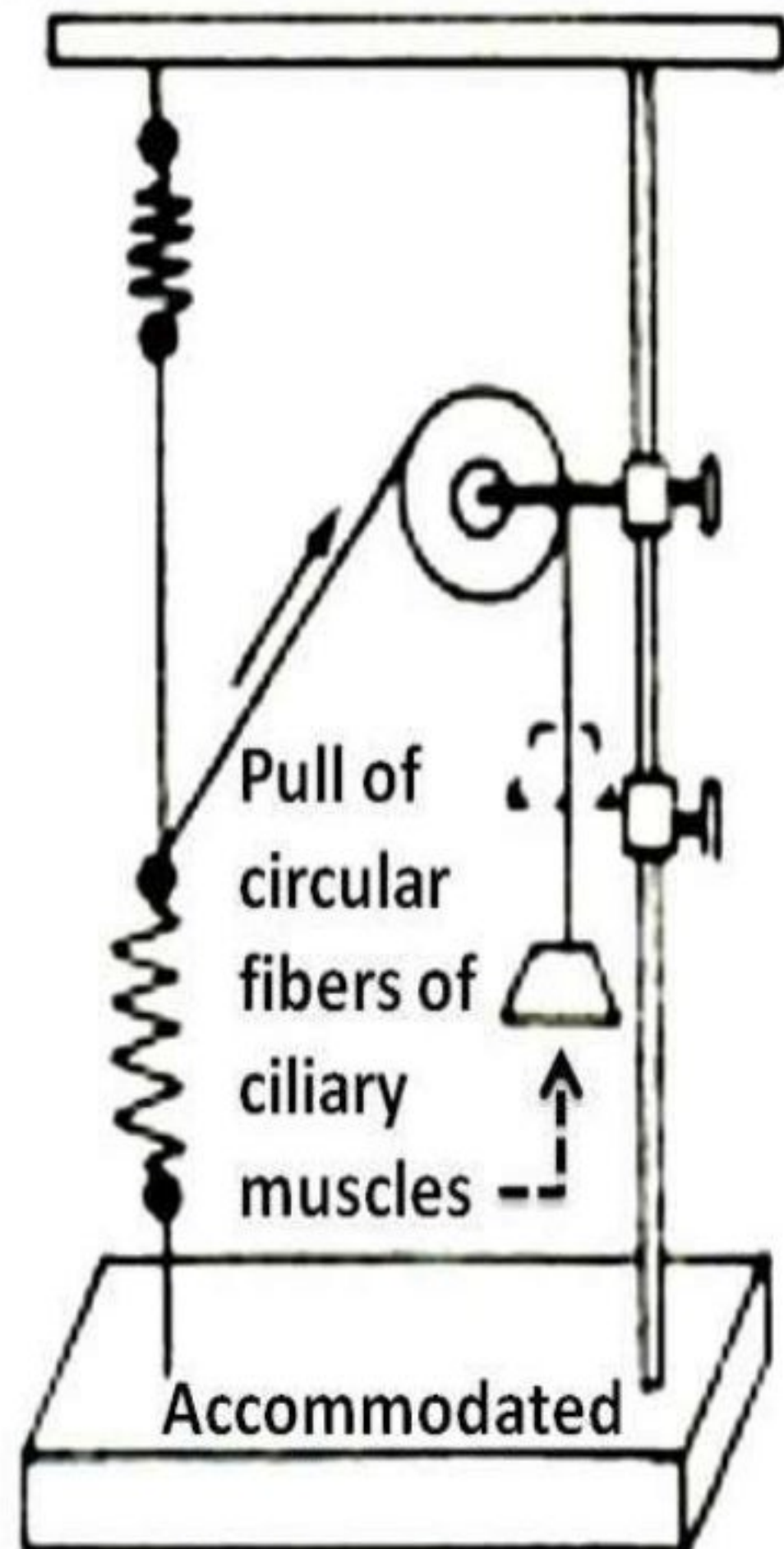
# Points in favour of the relaxation theory

- Imaging technique showed that ciliary muscle move anteriorly & the equatorial edge of lens move away from sclera during accommodation.
- Gonio-videography show zonular fibers extending from ciliary processes to lens equator, are relaxed during accommodation



# GULLSTRAND mechanical model of accommodation

- It is based on HELMHOLTZ hypothesis
- GULLSTRAND devised a mechanical model to explain accommodation.
- It shows in unaccommodated state elasticity of choroid is stronger than lens. When accommodation comes into play weight i.e ciliary muscles contract to overcome elasticity of choroid.
- It helps lens to take accommodated shape.

**A****B**

# Points against the theory

- It is not clear how lens alters its shape when tension in suspensory ligaments is relaxed?
- what is responsible for decline in power of accommodation with age?



# TSCHERNING'S THEORY OF ACCOMMODATION



increased curvature of capsule to increasing tension of the zonules.



It states that contraction of ciliary muscle pulls zonules directly

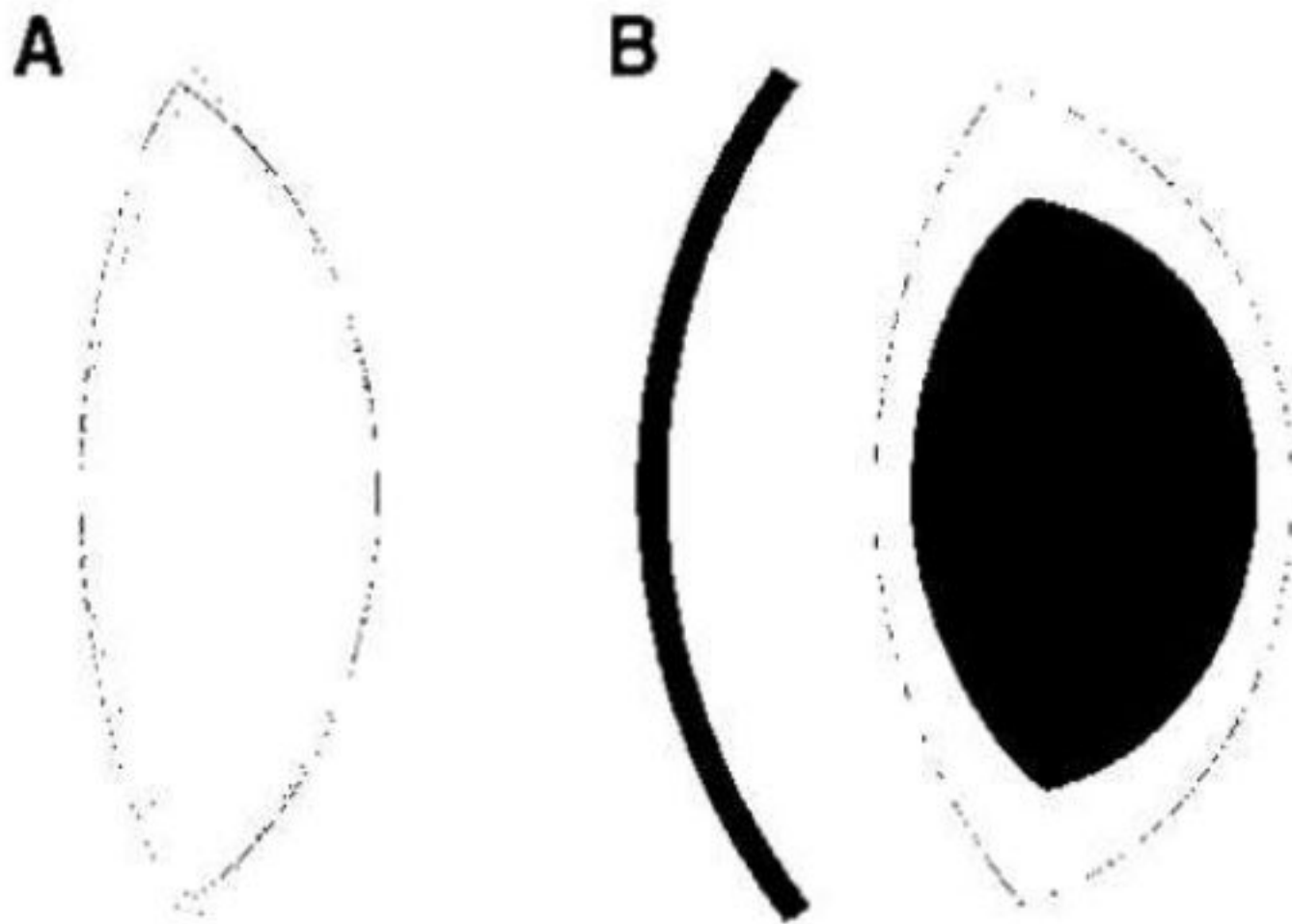


increases tension of capsule at equator of lens



bulging of poles.





**Figure 4** Tscherning (Ref. 28.) proposed an alternative mechanism of lenticular accommodation. (A) The unaccommodated lens is shown as a solid line with the accommodated lens superimposed as a dashed line. Tscherning believed that the accommodative change in the form of the lens occurred as a consequence of an increase in traction of the zonular fibers at the lens equator. Thus, as depicted by Tscherning, the unaccommodated lens has a larger diameter, but the lens undergoes no change in axial thickness. The anterior surface of the lens is to the left. (B) Tscherning believed this change in form of the lens occurred as a consequence of the relatively softer cortex being molded around the relatively hardened nucleus. He believed the surfaces of the nucleus to be more steeply curved than the surfaces of the lens. With an increase in traction of the zonular fibers at the lens equator the peripheral lens surfaces are flattened while at the middle of the lens the curvatures increase. The cornea and anterior lens surface are on the left of the diagram. (From Ref. 28.)

# SCHACHAR'S THEORY OF ACCOMMODATION

ciliary muscle contracts

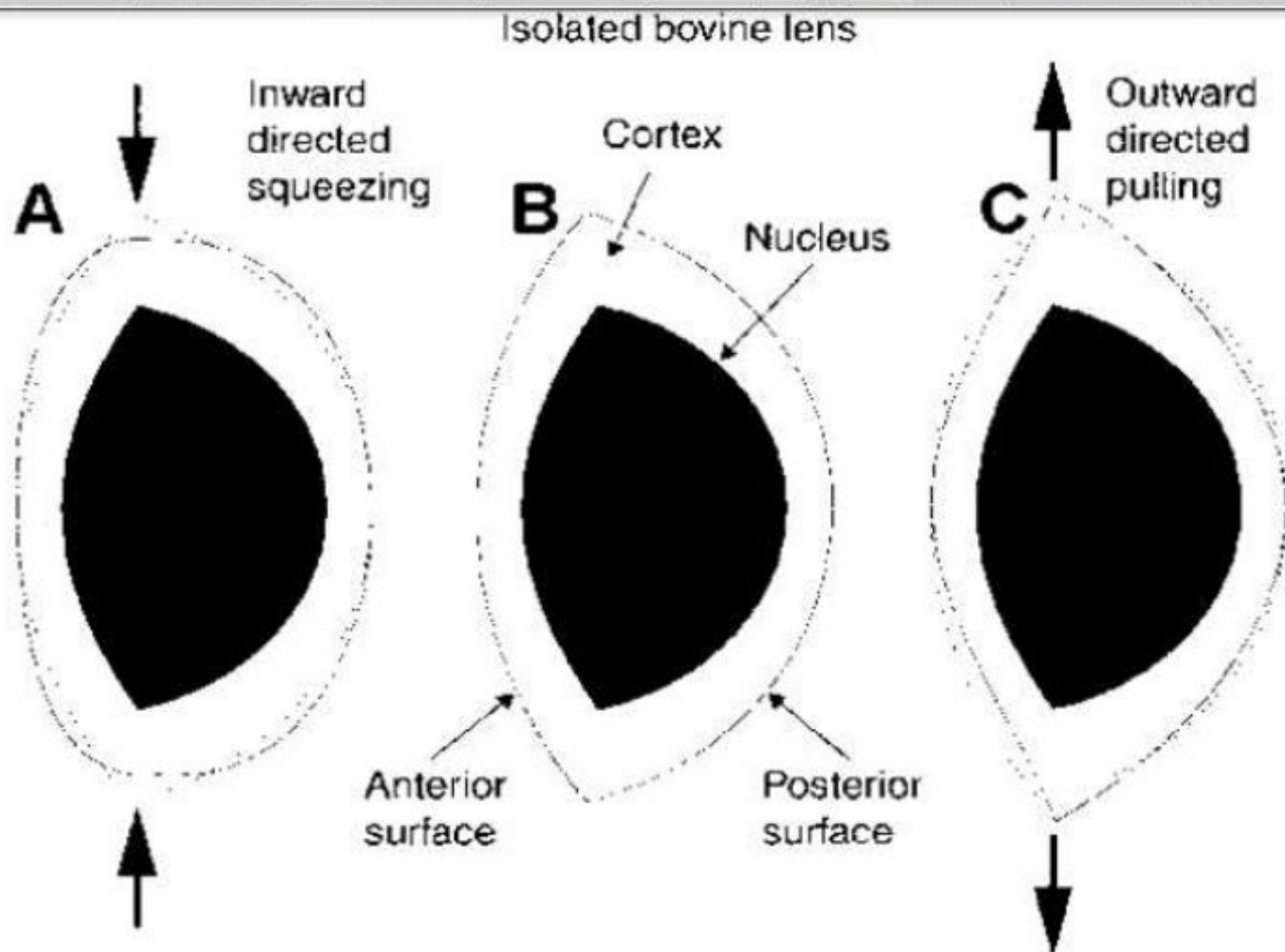
equatorial zonular tension is increased

anterior and posterior zonules are simultaneously relaxed

central surfaces of the lens steepen

peripheral surfaces of the lens flatten





**Figure 5** Tscherning (Ref. 28.), like Schachar et al. (33), performed experiments on bovine lenses. (A) When Tscherning applied a squeezing force to the equator of the bovine lens, a peripheral flattening and central steepening resulted (solid line) relative to unstressed lens (dashed line). (B) Tscherning believed that the nucleus was harder and had steeper curvatures than the surfaces of the lens and so provided a resistive force around which the cortex is molded. (C) When Tscherning applied a stretching tension to the lens equator (solid line), the softer lens cortex was molded around the hardened nucleus such that there is an increase in curvature at the center of the lens relative to the unstretched lens (dashed line). Note that there is no change in thickness of the lens with either

# COTENARY theory

A diagram on the left side of the slide shows a series of concentric blue arcs, representing the increasing curvature of the lens as accommodation occurs. The arcs are centered on the right side, where the text is located.

As ciliary muscle contracts

it forms a pressure gradient, causing anterior movement of lens zonules diaphragm

increasing anterior central curvature.

Presbyopia is due to increase in lens volume, results in reduced response to pressure gradient created by ciliary body contraction

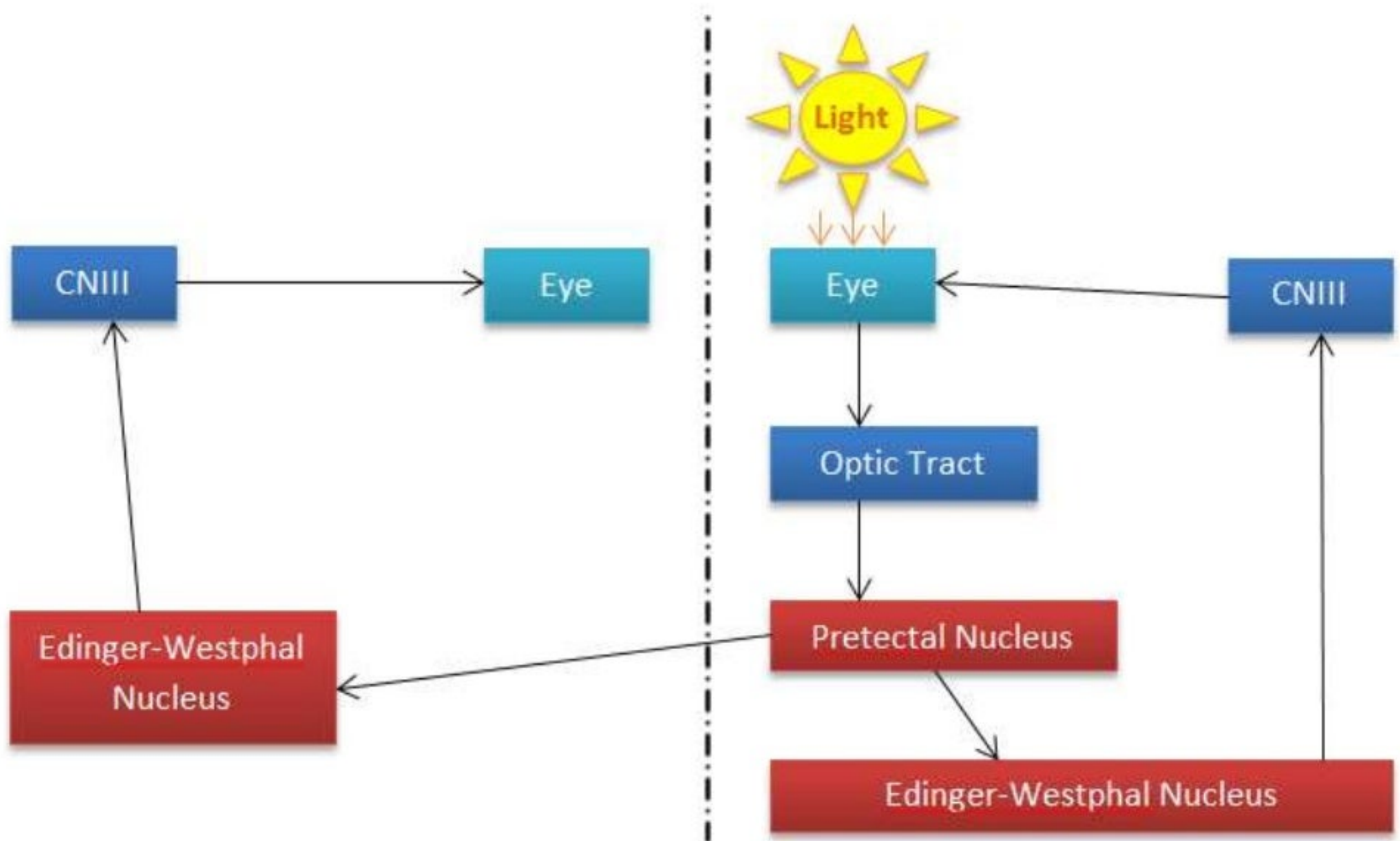


# Changes during accommodation

- During accommodation, lens diameter decreases
- Lens thickness increases
- The thickness of the nucleus increases, but without a change in thickness of the cortex
- central anterior surface curvature and lens posterior surface moves posteriorly to increase anterior segment length
- . Anterior chamber depth decreases due to the forward movement of the anterior lens surface and
- the vitreous chamber depth decreases due to the posterior movement of the posterior lens surface

- The lens asphericity changes and the pupil constricts.
- accommodation is accompanied by an increase in negative spherical aberration of the eye
- the iris constricts during accommodation, to decrease the optical entrance pupil of the eye

# Accommodation Reflex



# Near reflex

- The afferent
  - Retina (with the retinal ganglion axons in the optic nerve, chiasm and tract),
  - Lateral geniculate body (with axons in the optic radiations)
  - Visual cortex.
- Ocular motor control neurons are interposed between the afferent and efferent limbs of this circuit and include the visual association cortex



- It determines the image is "out-of-focus" & sends corrective signals

|

internal capsule and crus cerebri

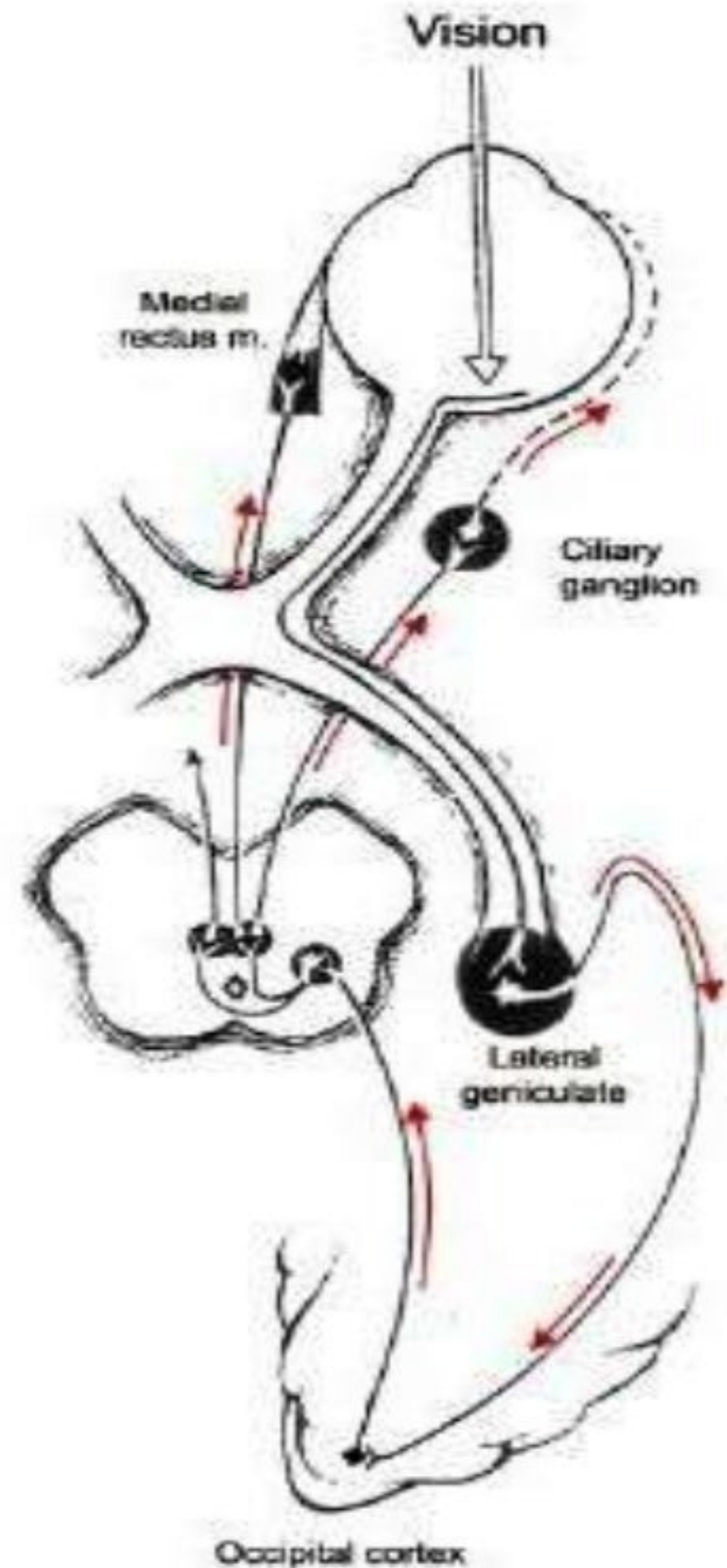
|

supraoculomotor nuclei (generates motor control signals)

|

oculomotor complex.

- The efferent
  - Edinger-Westphal nucleus - oculomotor nerve - ciliary ganglion - short ciliary nerve - iris sphincter and the ciliary muscle/zonules/lens of the eye
  - oculomotor neurons - oculomotor nerve - medial rectus, converge the two eyes.



- (1) **The far point** of distinct vision is the position of an object such that its image falls on the retina in the relaxed eye, i.e. in the absence of accommodation. The far point of the emmetropic eye is at infinity.
- (2) The **near point** of distinct vision is the nearest point at which an object can be clearly seen when maximum accommodation is used.



- The **range of accommodation** is the distance between the far point and the near point, the distance over which accommodation is effective.
- The **amplitude of accommodation** is the difference in dioptric power between the eye at rest with minimal refractivity and the fully accommodated eye with max. refraction.
- The dioptric power of the resting eye is called its **static refraction**.
- The dioptric power of the accommodated eye is called its **dynamic refraction**.



# Types

**Physical accommodation is an expression of actual physical deformation of lens measured in diopters**

**Physiological accommodation has a unit the myodiotre which is taken as the contractile power of the ciliary muscle required to raise the refractive power of lens by 1 D**

# Measurement of accommodation

- Subjective estimation of near reading distance overestimates the accommodative response amplitude, largely due to depth of field of the eye

- Objective measurement of accommodation can be done with autorefractor or an aberrometer as the eye changes focus from a distant target to a near target



# FORMULA

- To calculate the accommodative power required to focus an intermediate point within the range of accommodation
- $A = V - R$
- where  $A$  is the accommodative power required, in dioptres;
- $V$  is the dioptric value of the intermediate point;
- $R$  is the dioptric value of the far point (the far point distance in hypermetropia, being behind the eye, carries a negative sign).
- Thus, to focus an object at 1 m, the emmetropic eye must exert one dioptre of accommodative power ( $A = 1 - 0$ ).

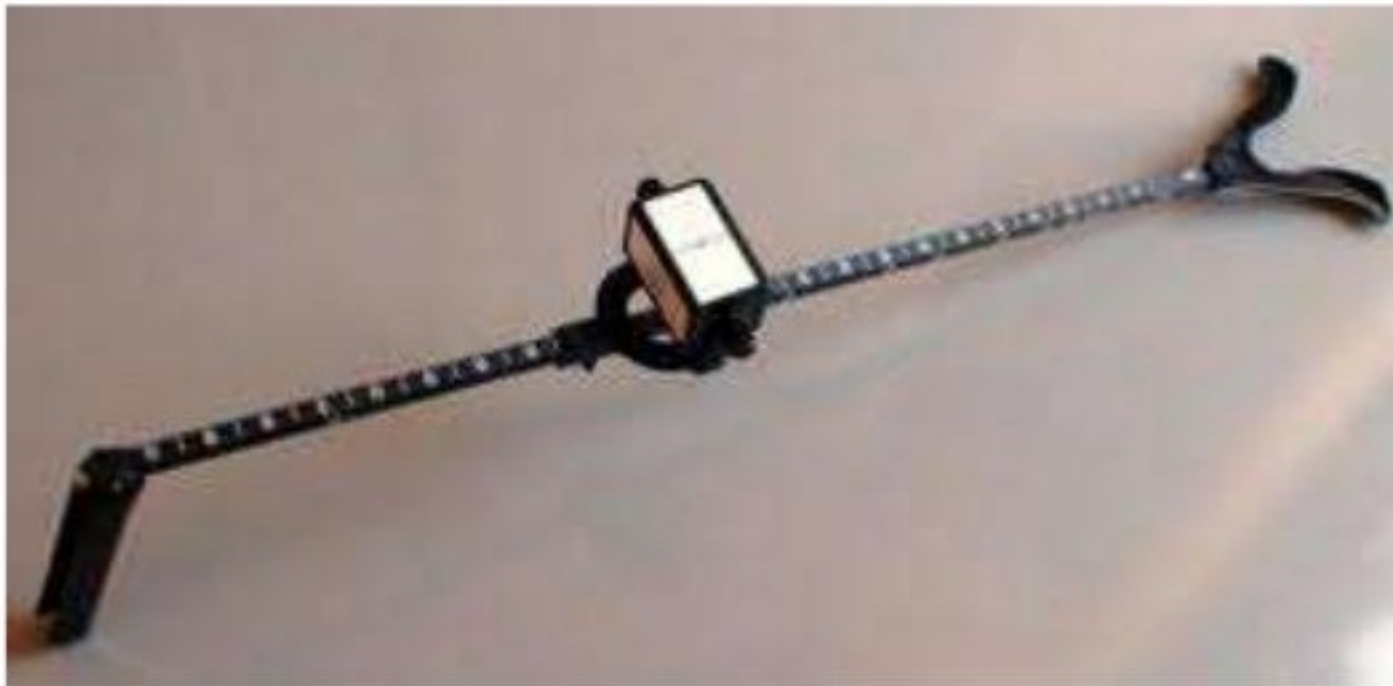
# Clinical Assessment

- Reading progressively smaller letters at near
- NPA using RAF rule
- Relative positive accommodation using minus lenses
- Accommodative flipper test using paired  $\pm$  lenses
- Dynamic Retinoscopy



# Clinical Assessment of NPA

- Measurement of NPA:
  - It is the closest point at which an object can be seen clearly
  - Also called “near point” or “punctum proximum”
  - Measured with the RAF rule



# Measurement of amplitude of accommodation

- Using minus lenses
- Each eye separately
- Best corrected near vn target at 40 cm
- Till pt reports first blur

Push up test

# Assessment of accommodative response

- Monocular estimation method retinoscopy
- Nott retinoscopy:
- Retinoscopic reflex is neutralized by moving retinoscope rather than adding the lenses



# Interpretation of accommodative response

- **Lead of Accommodation:** The amount by which the accommodative response of the eye is greater than the dioptric stimulus to accommodation
- **Lag of Accommodation:** The amount by which the accommodative response of the eye is less than the dioptric stimulus to accommodation

# Assesment of dynamic Accomodation

- An accomodative flipper of +2.00ds with - 2.00Ds is used to test accomodative facility
- Difficulty with plus lenses is seen in pts with accomodative excess
- Difficulty with minus lenses is seen in pts with prebyopes

# Accommodative Convergence/Accommodation Ratio

In order to view a near object

accommodate to ensure clear  
retinal images,

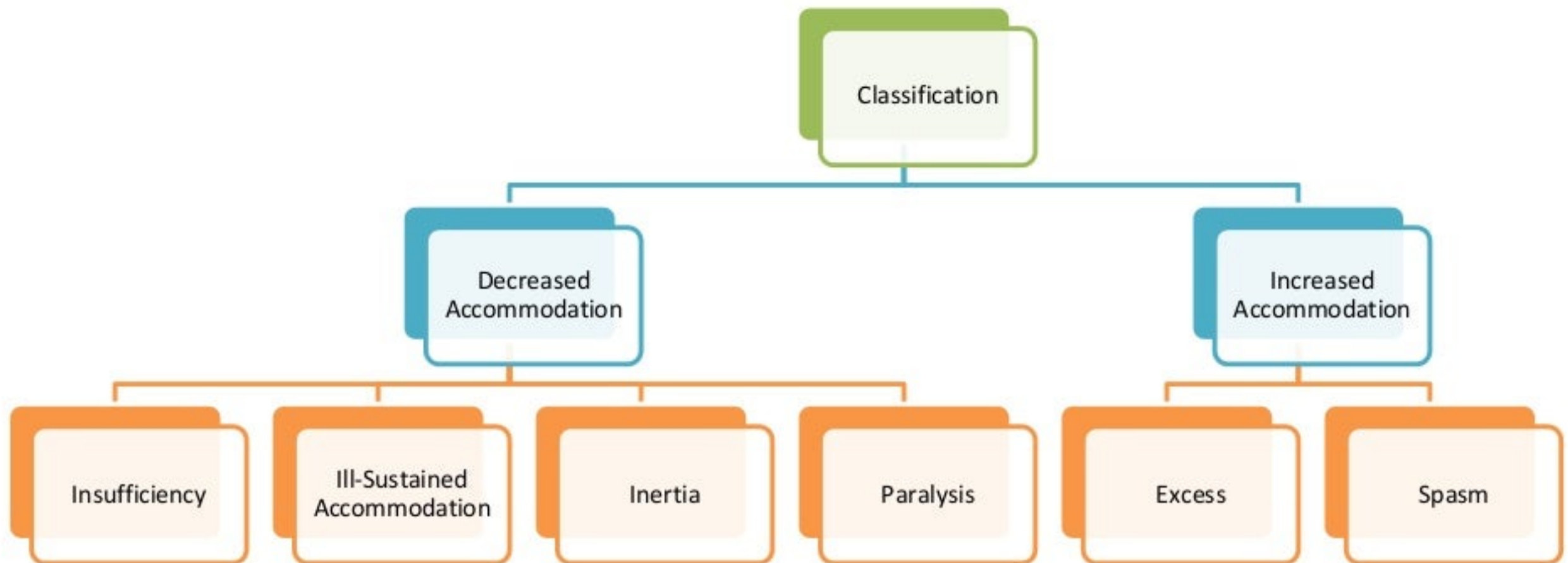
converge to maintain binocular  
single vision.

the number of prism dioptres of  
convergence which  
accompanies each dioptre of  
accommodation, ratio (AC/A)  
ratio.

The normal range for the AC/A  
ratio is 3:1 to 5:1.



# Anomalies of Accommodation



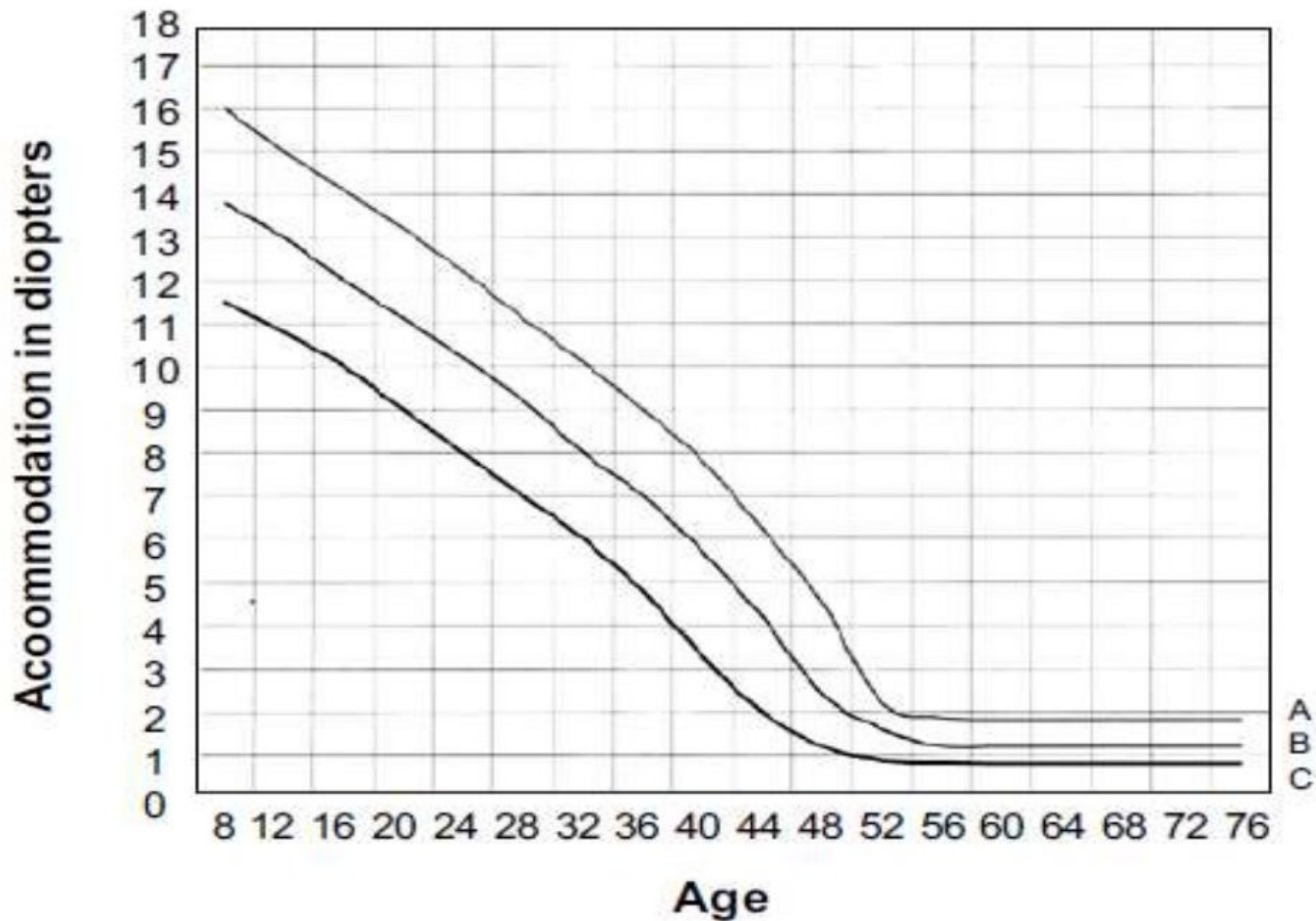
- Diminished or deficient accommodation
  - Physiological : Presbyopia
  - Pharmacological : Cycloplegia
  - Pathological
    - » Insufficiency of accommodation
    - » Ill sustained accommodation
    - » Inertia of accommodation
    - » Paralysis of accommodation
- Increased accommodation

# Presbyopia

Presbyopia is a condition of physiological insufficiency of accommodation leading to a progressive fall in near vision.







**Fig. 1 - Duane's standard curve of accommodation in diopters in relation to age (A: lowest values; B: average values; C: highest values).**

# Insufficiency of accommodation

- Condition in which accommodative power is constantly less than lower limit of normal range according to patient's age.

# Etiology



Premature sclerosis of lens

Weakness of ciliary muscle due to systemic causes: Debilitating illness, anemia, toxemia, malnutrition, diabetes mellitus, pregnancy, stress etc.

Weakness of ciliary muscle due to local causes: PAOG, mild cyclitis as during onset of sympathetic ophthalmia.



# Clinical features



- Features of eye strain and asthenopia.
- Head ach, fatigue & irritability of the eyes, while attempting near work.
- Near work is blurred & becomes difficult or impossible.
- Disturbance of convergence : intermittent diplopia.
- It is stable condition, if due to of lens.
- But is not stable in association ciliary muscle weakness.



# Treatment

- Identification & treatment of any systemic cause.
- Any refractive error should be corrected & if vision for near work is seriously blurred then additional near correction has to be prescribed same as presbyopia.
- If associated with convergence excess then full spherical correction.

- Convergence insufficiency is there, then base in prisms can be added.
- Prismatic correction added should bring near point of convergence to same distance as near point of accommodation.
- Weakest convex lenses should be prescribed, so as to exercise and stimulate accommodation.
- After recovery additional correction should be made weaker and weaker from time to time.



- Accommodative exercises.
  - While do exercises patient should wear correction for distance.
  - Should be done simultaneously in both eyes, even if associated with convergence insufficiency.
  - But with convergence excess then the exercise should done with one eye alternately.
  - Accommodation test card exercise.
  - Useless in generalized debility and sclerosis of lens.

# III-Sustained accommodation

- Accommodation fatigue.
- It is a situation in which though **range of accommodation is in normal range** but it cannot sustain it for a sufficient period of time.
- Initial stage of insufficiency of accommodation.
- It occurs due to
  - Stage of convalescence from debilitating illness
  - Stage of generalized tiredness
  - When the patient is relaxed in the bed

# Clinical features

- These symptoms are most commonly reported at the end of the day
- Blurred vision after prolonged near work.
- Headaches
- Eyestrain
- Fatigue, sleepiness and a loss of comprehension with continued reading
- A dull 'pulling' sensation around the eye.



# Treatment

- Near work should be curtailed during debilitating illness.
- General tonic measures should be taken.
- The condition of illumination and posture while doing near work, should be improved.

# Inertia of accommodation

- It is a condition in which patient faces difficulty in altering the range of accommodation.
- Amplitude of accommodation is normal.
- Ability to make use of this amplitude quickly and for long periods of time is inadequate.

# Clinical features

- Difficulty changing focus from one distance to another
- Headaches
- Eyestrain
- Fatigue
- Difficulty sustaining near tasks
- Blurred vision



Treatment: correcting any refractive error and accommodative exercises.



# Paralysis of accommodation

- parasympatholytic drugs
- Internal ophthalmoplegia
- Complete third nerve paralysis
- Systemic medications



# Clinical features

- Blurred vision at
- Photophobia or a 'dazzling'
- Diplopia
- Micropsia: objects may appear smaller than they are due to a false sense of distance
- Enlarged pupil.

**"Photophobia"**  
**The fear of light**



# Treatment



- An effort should be made to find out the cause and try to eliminate it.
- Self-recovery occurs in drug-induced paralysis and in diphtheric cases (once systemic disease is treated).
- Dark-glasses effective in reducing glare.
- Convex lenses for near vision, if the paralysis is permanent.



# Excessive accommodation

- Accommodative response is greater than the accommodative stimulus.
- There is functional increase in tonus of ciliary muscle, results in a constant accommodative effect.

# Causes

- Young hypermetropes frequently uses excessive accommodation as a physiological adaptation
- Young myopes performing excessive near work, associated with excessive convergence.
- Astigmatic error in young patients
- Presbyopes in the beginning
- Use of improper and ill fitting spectacles

# Precipitating factors

Excessive near work done, especially in dim or excessive illumination.

General debility, physical or mental ill health



# Symptoms



- Blurred vision at near is uncommon
- Blurred vision at distance
- Headaches
- Eyestrain
- Photophobia
- Difficulty changing focus from distance to near
- Diplopia



# Treatment



- It has a good prognosis.
- Refractive error should be corrected after carefully performed cycloplegic refraction.
- Near work should be stopped for some time, after that it should be done with proper illumination conditions.

# Spasm of accommodation

- Spasm of accommodation refers to exertion of abnormally excessive accommodation.







- Drug induced spasm of accommodation is known to occur after use of strong miotics.
- Spontaneous spasm of accommodation: attempt to compensate for a refractive anomaly.
- Occurs when excessive near work is done with bad illumination, bad reading position, state of neurosis, mental stress or anxiety.



# Clinical features

- Defective vision: due to induced myopia
- macropsia.
- Asthenopic symptoms
- Precipitating factors like marked degree of muscular imbalance, trigeminal neuralgia, a dental lesion, general intoxication.



# Treatment

- Relaxation of ciliary muscle by atropine for 4 weeks or more and
- Prohibition of near work allow prompt recovery from spasm of accommodation.
- Elimination of the associated causative factors to prevent the recurrence.