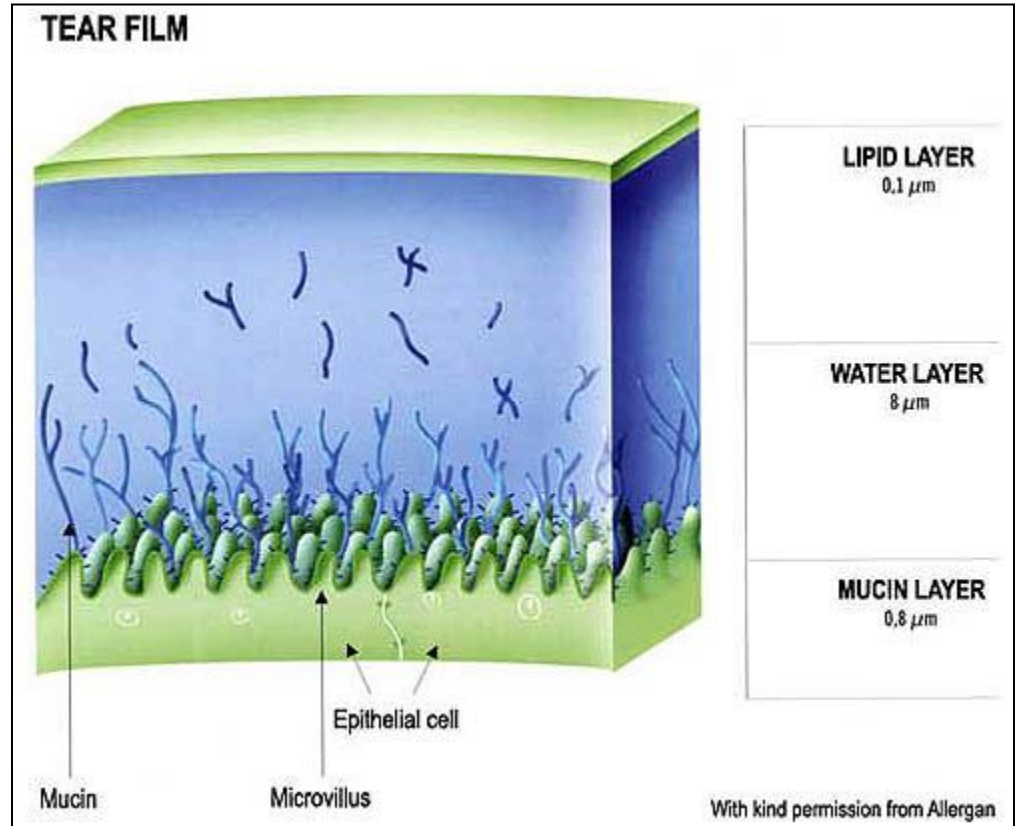
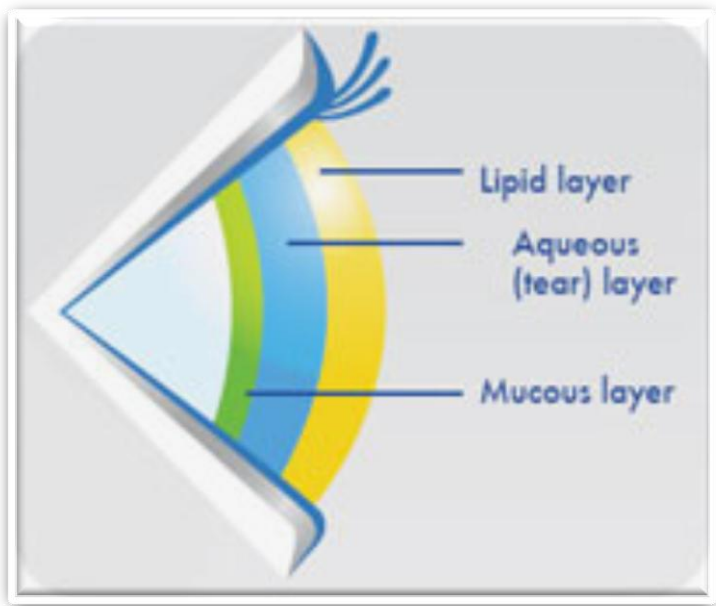



Tear film

sourav

Layers of tear film



Functions of tear film




Forms a perfectly smooth optical surface on the cornea by filling in small surface irregularities in corneal epithelium

Helps to keep the surface of cornea and conjunctiva moist

Acts as a lubricant for pre ocular surface and lids – decreases the frictional forces due to constant blinking

Transfers oxygen from atmosphere to cornea

Functions of tear film



Prevents infection due to presence of antibacterial substances such as lysozyme, betalysin, lactoferrin, immunoglobulins and other proteins

Washes away debris and other noxious irritants

Provides pathway for WBCs in case of injury

Lipid layer

- Derived from secretions of Zeis, Moll and meibomian glands
- Prevents overflow of tears and retards their evaporation

Aqueous layer

- Secreted by lacrimal gland and accessory glands of krause and wolfring
- Maintain bulk of thickness contribution
- Low viscous layer
- Provides oxygen to epithelium
- Washes away debris



Mucus layer:

- Secreted by conjunctival goblet cells, crypts of Henle and glands of Manz
- Lubricates the ocular and palpebral surfaces making the friction during blinking and eye movements minimal
- Plays an important role in the stability of tear film
 - Mucin secreted by goblet cells, spread by action of lids
 - Get adsorbed on the cell membrane of epithelial cells
 - Anchored by microvilli forming a hydrophilic surface on which aqueous and lipid layer spread

Physical properties of tear film

- Salty, alkaline and watery
- Average thickness: $4\mu\text{m}$ to $8\mu\text{m}$
- Volume: $7\mu\text{l}$
- Rate of secretion: $1.2\mu\text{l}/\text{min}$
- Refractive index: 1.357
- PH: average 7.4
- Temperature: normal blink rate, open eye condition 30°C to 35°C
- Oxygen tension: 40 to 160mmHg

Tear film dynamics

Formation of tear film

Retention and distribution of tear film

Displacement phenomenon

Evaporation from tear film

Drying and breakup of tear film

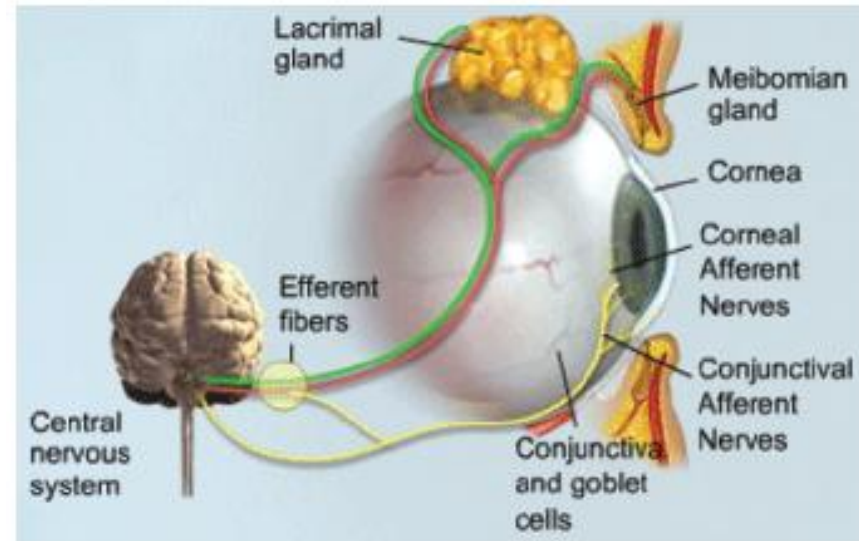
Dynamic events during blinking

Elimination of tears

Secretion of tears

- Basal tears – accessory lacrimal glands
- Reflex – main lacrimal glands
- Reflex – occurs in response to sensations from cornea and conjunctiva
- Reflex – due to evaporation and break up of tear film
- Tear secretion:
 - Afferent pathway - fifth nerve
 - Efferent pathway - parasympathetic supply of lacrimal gland

■ Figure 1. Lacrimal Functional Unit

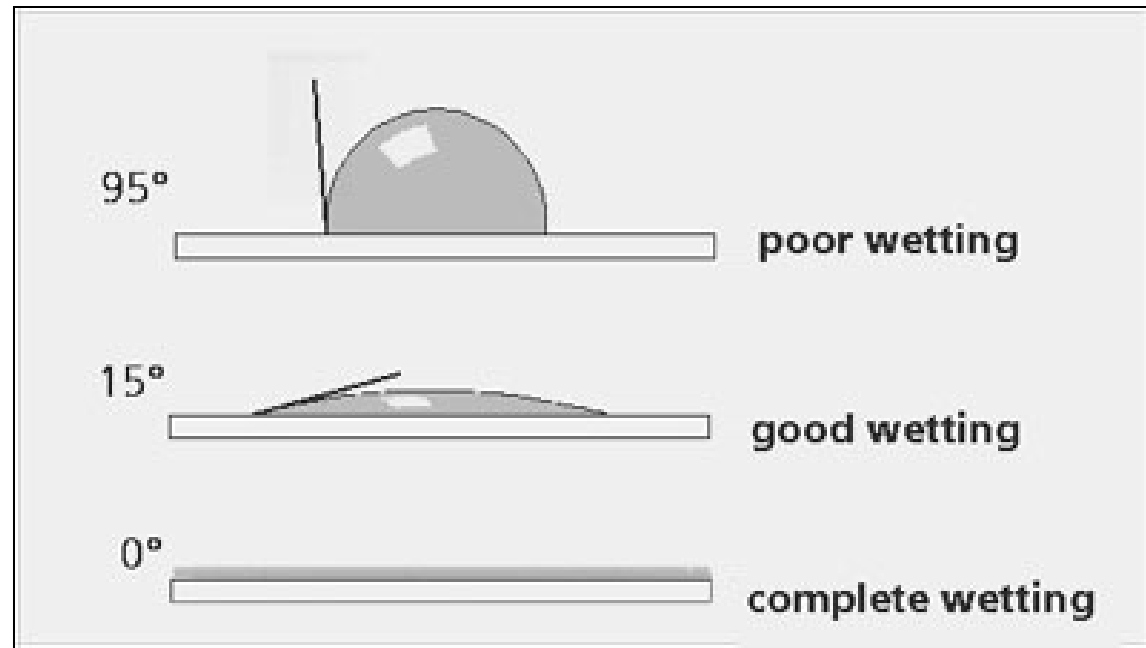


Secretion of tears

- Excess tears noted only after 4 months
- New born – even on loud crying – no excessive tears
- Secretions of main & accessory lacrimal gland, meibomian gland, mucous gland make up the lacrimal fluid
- Flows over the ocular surface and a continuous preocular tear film is formed

Formation of pre-ocular tear film

- Wettability: defined by tendency of liquids to spread on the surface
- $> 90^\circ$ - hydrophobic
- $> 0^\circ$ to 90° – relatively hydrophobic
- 0° - hydrophilic



Formation of pre-ocular tear film

- Thin layer of mucus secreted by conjunctiva is formed on cornea
- Over this aqueous component spreads spontaneously
- Then lipid layer spreads contributing to stability and retardation of evaporation between blinks

Retention and redistribution of tear film

- Tear film is retained at a uniform thickness over the cornea against the gravitational force
- Corneal epithelium along with mucopolysaccharides play a role in retention of tear film
- Redistribution by blink mechanism

Evaporation from tear film

- Low humidity and turbulent air flow
- Lipid layer
- Evaporation is 10% of production
- $0.12\mu\text{l}/\text{min}$

Stability and rupture of tear film

- Tears can function properly only if the tear film covers the entire precorneal surface and re-established completely after a blink
- When blinking is prevented for a brief interval of 15 to 40 seconds tear film ruptures
- At least 10 minutes is required for the whole tear film to evaporate

Mechanism of tear film breakup

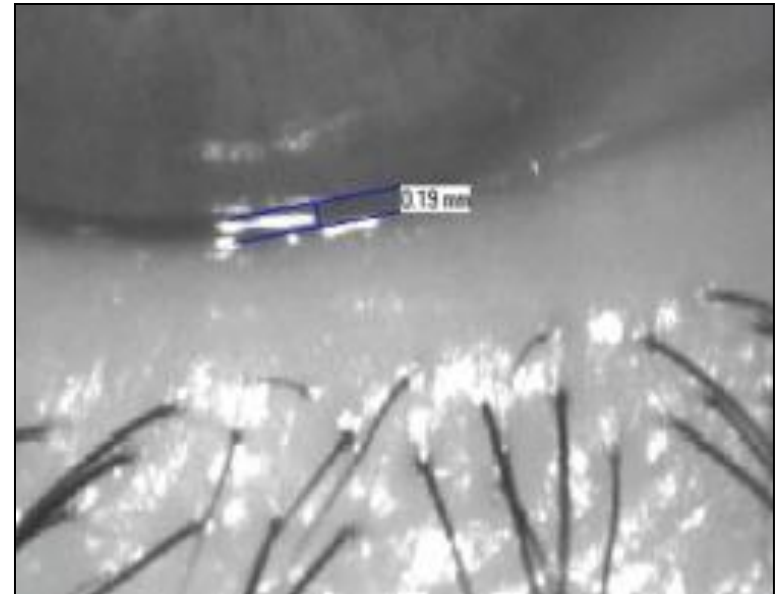
- All tear film decreases in thickness uniformly
- When tear film is thinned out to some critical thickness, significant number of lipid molecules begin to be attracted by mucin layer
- When the mucin layer in epithelium is sufficiently contaminated by lipid, the mucin becomes hydrophobic and the tear film ruptures
- Blinking repairs the rupture by removing the lipid contaminant from mucin layer and restoring a thick aqueous layer

Dynamic events during blinking

- As upper eyelid move downwards superficial layer is compressed
- Lipid layer along with biopolymers is compressed between lid edges
- No epiphora occurs as the compressed thickness is only $0.1\mu\text{m}$
- Lipid contaminated mucus is rolled up like a thread and dragged into lower fornix

Dynamic events during blinking

- When eye opens – lipid forms a monolayer
- Multimolecular layer
- Drags aqueous tears
- Tear meniscus



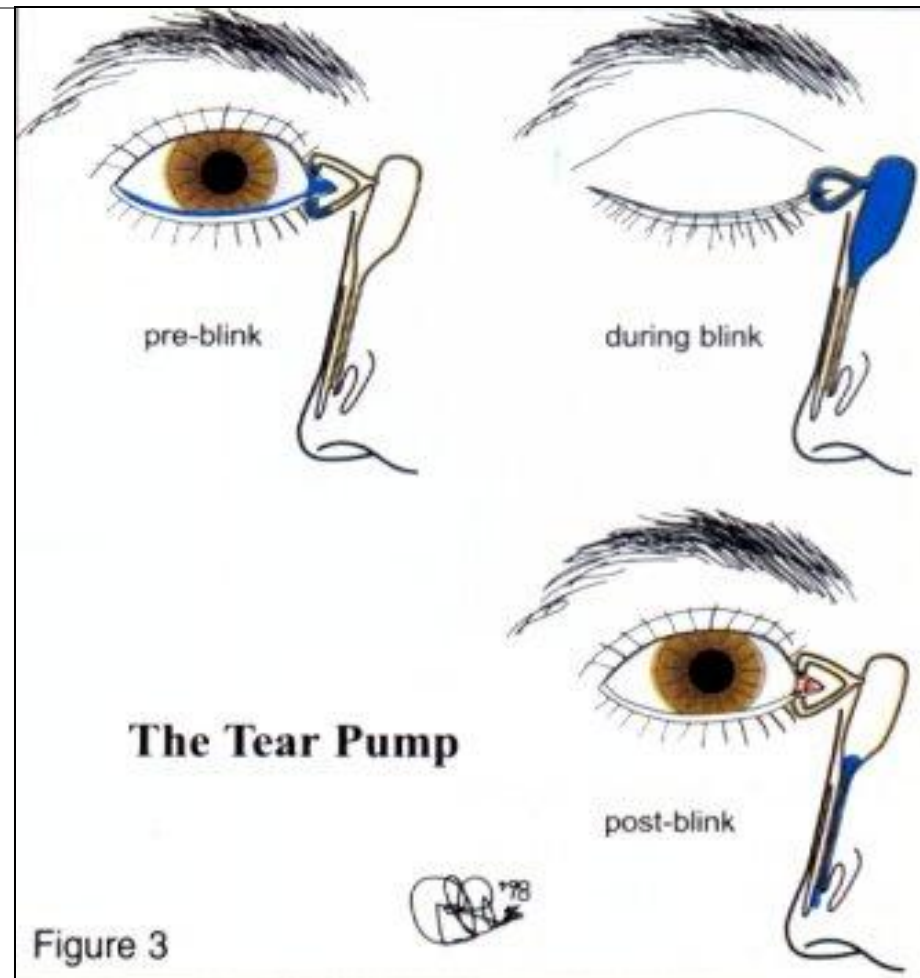
Drainage of tears

- Lacrimal fluid flows over the preocular surface
- Reaches marginal tear strip running along the ciliary margin of eyelid and in the inner canthus
- Drained by lacrimal apparatus into nasal cavity

Lacrimal pump mechanism

Eyelids closed

- Contraction of pretarsal fibres of orbicularis compress the ampulla and shorten canaliculi
- Tears from ampulla and horizontal canaliculi flows towards lacrimal sac
- Contraction of preseptal fibers orbicularis pull the lacrimal fascia and lateral wall of lacrimal sac laterally, thereby opening the normally closed lacrimal sac



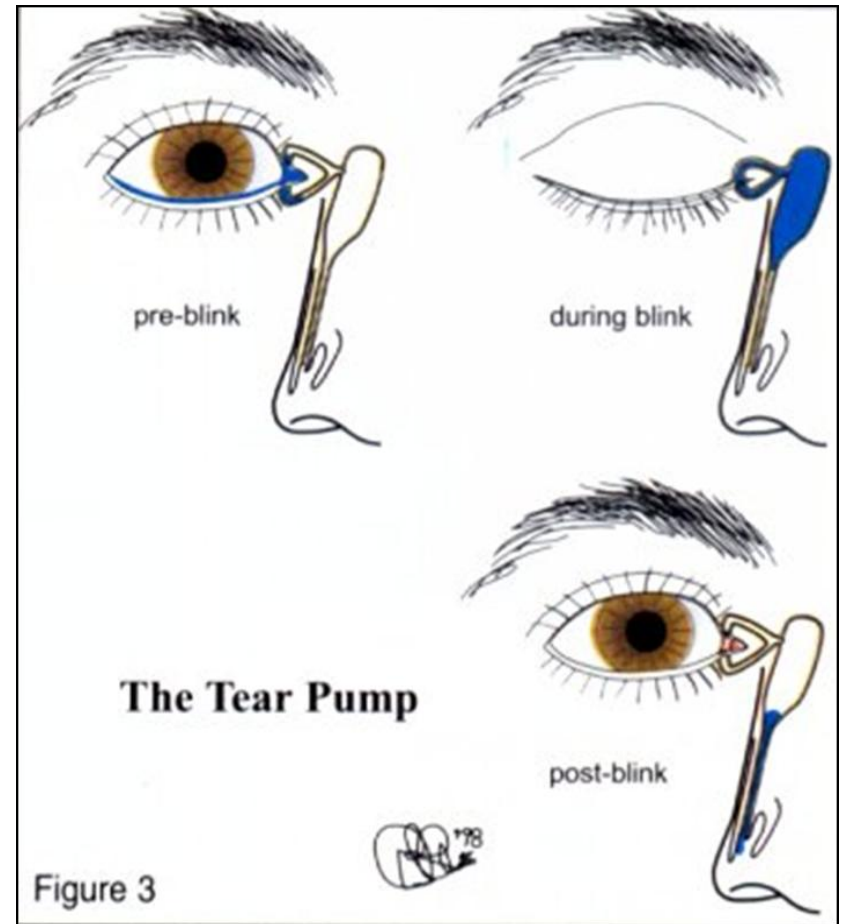
Lacrimal pump mechanism

- Negative relative pressure is created and draws the tears from canaliculi into lacrimal sac
- Along with increased tension on the lacrimal fascia the inferior portion closes more tightly, thereby preventing aspiration of air from the nose

Lacrimal pump mechanism

Eyelids opened

- Tone in orbicularis muscle is decreased
- Relaxation of pretarsal fibers of orbicularis allow the canaliculi to expand and reopen
- Lacrimal sac collapse and expels the fluid down into nasolacrimal duct
- Lacrimal fluid drawn through puncti from lacrimal lake



Factors which influence the flow of tears along NLD

- Gravity helps in downward flow
- Air current movement within nose:
 - The opening of NLD in nasal cavity is placed in such a way that air currents passing either inward or outward induce a negative pressure and draws the fluid down
- Hasner's valve present at the lower end of NLD remains open as long as the pressure within the nose is less than the NLD and allows the tears flow from NLD to nose

Tear film abnormalities

- Aqueous deficiency: (eg) keratoconjunctivitis sicca
- Mucin deficiency: (eg) Stevens-Johnson syndrome
- Lipid abnormality: (eg) chronic blepharitis

Tear film function test



- Schirmer test:
- Whatman filter paper number 41 (5x35mm)
- Placing it in lower fornix
- At the junction of outer $1/3$ and inner $2/3$
- For 5 minutes
- Measure the wetting in the strip
- Gives total of basal and reflex



Tear film function test

- Basal secretion: reflex is arrested by topical anesthesia
- Reflex secretion: by stimulating nasal mucosa with cotton and measurement is noted after 2 minutes
- Measurement I

Tear film breakup time (TBUT)

- Fluorescein dye
- Cobalt blue filter
- Time interval between a complete blink and appearance of first randomly distributed dry spot on cornea
- Break up time of less than 10 seconds is abnormal

