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Blackboard Learn
https://cms.blazernet.uab.edu/cgi-bin/bb9login
My Calendar (Blackboard)

8:30 AM - 10:00 AM on 10/18/11:
Class 1 Ocular fluids blood tear film aqueous and vitreous humor crystallin proteins and cataract (Dr. Gross)

8:30 AM - 9:00 AM on 10/20/11:
Quiz 1

9:00 AM - 10:00 AM on 10/20/11:
Class 2 ocular proteins collagen sclera (Dr. Gross)

8:30 AM - 10:00 AM on 10/25/11:
Class 3 phototransduction, part 1 (Dr. Gross)
Ocular Fluids- outline

• Water
• Blood
• Aqueous and vitreous fluid
• Precorneal tear film
• Crystallins and cataract
Ocular Fluids

• Common fluids (with non-ocular regions):
  – Cell cytoplasm
  – Interstitial fluid
  – Blood

• Ocular-specific fluids:
  – Aqueous fluid
  – Vitreous fluid
  – Precorneal tears

*Eye composed of ~80% fluid!
Water is unusual...

Normal metabolic activity can only occur when cells contain ≥ 65% water

- Water and its ionization products (H⁺ and OH⁻) are critical determinants of many biomolecules (membranes, phospholipids, nucleic acids, amino acids, protein structure and function, etc.)

- Δ [H+] on either side of a bilayer: energized state crucial to biological mechanisms of energy transfer
Unexpected properties!

- Water = hydride of oxygen
  - Nearest neighbors: ammonia (NH$_3$), hydrogen fluoride (HF) sulfur (H$_2$S)
  - H$_2$O: higher boiling point, T$_m$, heat of vaporization, surface tension
  - Intermolecular forces of attraction between H$_2$O molecules are high

State at standard temperature and pressure

- Atomic number in red: gas
- Atomic number in blue: liquid
- Atomic number in black: solid

solid border: at least one isotope is older than the Earth (Primordial elements)
dashed border: at least one isotope naturally arise from decay of other chemical elements and no isotopes are older than the earth
dotted border: only artificially made isotopes (synthetic elements)
no border: undiscovered
• Water has an unusual dielectric constant (high) 
  (a measure of a solvent’s ability to keep opposite charges apart)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Dielectric constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formamide</td>
<td>110.0</td>
</tr>
<tr>
<td>Water</td>
<td>78.5</td>
</tr>
<tr>
<td>Ethanol</td>
<td>24.3</td>
</tr>
<tr>
<td>Ammonia</td>
<td>16.9</td>
</tr>
<tr>
<td>Benzene</td>
<td>2.3</td>
</tr>
<tr>
<td>Hexane</td>
<td>1.9</td>
</tr>
</tbody>
</table>

• Maximum density found in the liquid state
• Negative volume of melting

Key: unrivaled ability to form hydrogen bonds is a crucial fact to understanding its properties

(go to chimera)
• 2 H atoms covalently attached to oxygen, sharing e\(^{-}\) pair
• polar (non-linear arrangement); EN O atom & 2x H form dipole
• Bent structure: enormous influence on properties. Potential to form 4 H-bonds per water molecule is the source of strong intermolecular attractions that give this molecule its unexpected properties
• \([H^+]\) in cells = 1 x 10\(^{-7.4}\) M \((pH = 7.4)\)
Ice

• Each molecule has 4 nearest neighbors to which it is H-bonded
• 3D network of H-bonds: directional and straight
  • H-bonds are strong
• Open lattice-structure; density of ice is only 57% that expected for a tightly packed arrangement
Hydrogen bonds are weak.
Hydrogen bonds are strong.

• Hydrogen bonds are structurally characterized by an H⋯A distance that is at least 0.5 Å shorter than the calculated van der Waals distance. In water, the O⋯H hydrogen bond distance is ~1.8 Å vs 2.6 Å for the corresponding van der Waals distance.

• The energy of a hydrogen bond (~20 kJ/mol in water) is small compared to covalent bonds (~460 kJ/mol for an O-H covalent bond).

• The sheer number of H-bonds in a given molecule gives significant strength overall and is crucial in determining the molecule’s 3D structure and intermolecular interactions.
Water as a solvent

Solubility depends upon the ability of the solvent to interact with a solute more strongly than solute particles interact with each other.

- Polarity of water makes it an excellent solvent for polar and ionic materials (_substr: hydrophobic; Greek)

- Non-polar substances are insoluble in water but soluble in non-polar substances such as DMSO or CCl₄ (hydrophobic)
Ocular Fluids- outline

- Water
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Blood

- Essentially all other fluids in eye are simply filtrates of blood
- Functions: nourishment, waste disposal, generation of intraocular pressure, homeostasis of retinal functions
- Complex mixture of cellular and biochemical components with different densities
- pH ranges 7.33 – 7.45
- Gasses carried: O₂, N₂, CO₂
<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>albumin</td>
<td>3.8 – 5 g/dL</td>
<td>protein that carries insoluble blood components (lipids)</td>
</tr>
<tr>
<td>calcium</td>
<td>4.2-5.4 mg/dL</td>
<td>Ion involved in enzyme activation, muscle contraction, cell-cell adhesion</td>
</tr>
<tr>
<td>cholesterol</td>
<td>140-250 g/dL</td>
<td>Lipid carried in lipoproteins used to make hormones. Structural component in membranes</td>
</tr>
<tr>
<td>globulin</td>
<td>2.3-3.5 g/dL</td>
<td>Several related components, incl. immunoglobulins</td>
</tr>
<tr>
<td>glucose</td>
<td>70-105 mg/dL</td>
<td>Sugar nutrient &amp; source of carbohydrate polymers</td>
</tr>
<tr>
<td>hemoglobin</td>
<td>13-16 g/dL</td>
<td>Oxygen carrying protein of the RBCs</td>
</tr>
<tr>
<td>phosphate</td>
<td>3-4.5 mg/dL</td>
<td>Buffer component, reactant in enzymatic functions</td>
</tr>
<tr>
<td>potassium</td>
<td>~105 mmol/L</td>
<td>Cation, essential for several enzymatic reactions</td>
</tr>
<tr>
<td>triacylglycerols</td>
<td>35-140 mg/dL</td>
<td>Lipids carried in lipoprotein bodies</td>
</tr>
</tbody>
</table>
• Blood enters many vascular beds in the eye to nourish both the local tissues and supply fluid.

• This includes the **ciliary body** (for the aqueous); **the choroid** (for the retina) and vascular beds supplying the iris and the cornea.

• The retina’s nourishment is also supplied by the central retinal artery which nourishes the inner part of the retina.

• The lens has no direct supply of blood.

http://webvision.med.utah.edu/book
Dr. Helga Kolb
The aqueous fluid

This fluid is a product of the pumping activity of NaK-ATPase (primarily) and bicarbonate-ATPase (secondarily). The enzymes are located in the basolateral borders of the non-pigmented, epithelial cells of the ciliary body.

Even though they (Na,K-ATPases) only pump out one Na\(^+\) with each enzymatic cycle, the ciliary body holds many Na,K-ATPases (huge net effect!)

The role of HCO\(_3\)-ATPase is not known, but it may support Na,K-ATPases by creating a local pH environment that optimizes its activities.

There is little evidence to support the formation of aqueous as an ultrafiltrate alone.
The aqueous fluid

• Nourishes cells of posterior cornea, iris and lens

• Sole source of nourishment for cells of the corneal endothelium, stromal keratocytes, most of the corneal epithelial cells & the entire lens

• Source of antioxidants for lens

• Analogous to interstitial fluid: no red blood cells present, but it carries O₂

• Hydrostatic pressure (intraocular pressure or IOP) exerted by the aqueous maintains the shape of the ocular globe & protects it from physical stress/ shock
The aqueous fluid is a filtrate of blood

<table>
<thead>
<tr>
<th>component</th>
<th>Δ [component], aqueous vs. blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>albumin</td>
<td>↓</td>
</tr>
<tr>
<td>ascorbic acid (vitamin C)</td>
<td>↑</td>
</tr>
<tr>
<td>bicarbonate</td>
<td>UC</td>
</tr>
<tr>
<td>calcium</td>
<td>↓</td>
</tr>
<tr>
<td>cholesterol</td>
<td>↓</td>
</tr>
<tr>
<td>other lipids</td>
<td>↓</td>
</tr>
<tr>
<td>globulin</td>
<td>UC</td>
</tr>
<tr>
<td>other proteins</td>
<td>↓</td>
</tr>
<tr>
<td>pH</td>
<td>↓</td>
</tr>
<tr>
<td>potassium</td>
<td>↓</td>
</tr>
</tbody>
</table>
The vitreous humor

- Mixture of fluid and gel

- Composition varies with age, and between species

- Humans: begins at 80% gel / 20% fluid but gradually changes to 40% gel / 60% fluid (can cause retinal detachments, as the pockets of fluid are not uniform)

- Gel-like composition due to type II (and some other) collagens and proteoglycans (s.a. hyaluronic acid)

- Change in composition of gel/fluid is due to degradation of collagens

- Provides viscoelasticity (shock absorbing properties)
The vitreous humor is a filtrate of blood

<table>
<thead>
<tr>
<th>component</th>
<th>Δ [component], vitreous vs. blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>ascorbic acid (vitamin C)</td>
<td>[↑]</td>
</tr>
<tr>
<td>bicarbonate</td>
<td>UC</td>
</tr>
<tr>
<td>glycosaminoglycans (hyaluronic acid)</td>
<td>[↑]</td>
</tr>
<tr>
<td>protein</td>
<td>[↑]</td>
</tr>
<tr>
<td>glucose</td>
<td>[↓]</td>
</tr>
<tr>
<td>potassium</td>
<td>[↓]</td>
</tr>
</tbody>
</table>
Ocular Fluids- outline

- Water
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- Precorneal tear film
- Crystallins and cataract
Precorneal tears

- Coating the outer surface of the cornea is a “pre-cornea tear film.” Humans normally blink the eyelids of their eyes once every ~6 sec to replenish the tear film.

- Tears form a film between the inside of lids and cornea when the eyes are closed, remain for a short period of time after lids are open.

- 4 main functions:
  - Wetting the corneal epithelium (••: reducing dryness damage)
  - Creates smooth surface (a-la Rain-X)
  - Main supplier of oxygen to cornea
  - Destroys bacteria (via lysozyme), prevents growth of microcysts & flushes other microbes away from eye into lacrimal canals & out through nose.

http://webvision.med.utah.edu/book
Dr. Helga Kolb
Precorneal tear film

The aqueous portion of the tear film is generated primarily by the main lacrimal gland that also contributes proteins and electrolytes (cations and anions) to this layer.

In general, the components of the aqueous tears are more dilute than that of blood...
**Tear film is a filtrate of blood**

<table>
<thead>
<tr>
<th>Component</th>
<th>Δ [component], vitreous vs. blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>ascorbic acid</td>
<td>↓</td>
</tr>
<tr>
<td>(vitamin C)</td>
<td></td>
</tr>
<tr>
<td>bicarbonate</td>
<td>UC</td>
</tr>
<tr>
<td>calcium</td>
<td>↓</td>
</tr>
<tr>
<td>sodium</td>
<td>↓</td>
</tr>
<tr>
<td>protein</td>
<td>↓</td>
</tr>
<tr>
<td>glucose</td>
<td>↓</td>
</tr>
<tr>
<td>potassium</td>
<td>(nearly 7X!) ↑↑</td>
</tr>
</tbody>
</table>

• Low [glucose] = tears cannot nourish corneal and conjunctival cells—corneal cells are dependent upon aqueous fluid and conjunctival cells use interstitial fluid from their local blood supply for nourishment.
Ocular Fluids- outline

• Water
• Blood
• Aqueous and vitreous fluid
• Precorneal tear film

• Crystallins and cataract
Objectives of this section:

1) To describe crystallin family of proteins
   a) types
   b) MWS and structures
   c) characteristics
   d) roles in the lens

2) To explore the changes that occur in lens with aging

3) To describe senile cataract formation
   and its relationship to changes in crystallins
• The average adult human lens is \(~5\) mm thick with a diameter of \(~9\) mm.
• The outer edge of the lens consists of a single layer of epithelial cells & a membrane that surrounds the entire organ.
• Lens epithelia do not divide except when undergoing repair.
• Some epithelia lose their nuclei and other organelles (for transparency) and become lens fiber cells.
• There is very little protein turnover in lens fiber cells, \(\because\) damage to lens proteins accumulate throughout life.
The lens has 3 main parts:

*Lens capsule* (smooth, transparent basement membrane that completely surrounds the lens). Elastic, composed of type IV collagen & sulfated glycosaminoglycans (gags).

*Lens epithelium* (anterior portion of the lens between the lens capsule and lens fibers). Regulates most of the homeostatic functions of the lens: Na\(^+\)/K\(^+\) ATPases keep water and current flowing through the lens as liquid enters the lens from the aqueous humor.

*Lens fibers* (bulk of the lens). Long, thin, transparent cells, firmly packed. Diameters \(~4-7\) um & lengths up to 12 mm. Stretch lengthwise from posterior to anterior poles. Linked together via gap junctions.
Crystallins are water-soluble proteins that compose over 90% of the protein within the lens. They form soluble, high molecular weight aggregates that pack tightly in lens fibers, thus increasing index of refraction of the lens while maintaining its transparency.

These proteins are related to heat shock proteins (α-crystallins) and a bacterial spore coat protein (β and γ-crystallins).

Crystallins have been found in heart, brain and lung as well as in the cornea of the eye. They are water soluble proteins and their role in the lens is structural.
• Crystallins were initially classified according to their ability to migrate in an electrophoretic field

• The largest proteins were called the $\alpha$-crystallins and so on

• The molecular weights of these proteins were first estimated at $\sim 750,000$ for the $\alpha$-crystallins; $\sim 70,000$ for the $\beta$-crystallins; and $20,000$ for the $\gamma$-crystallins.
<table>
<thead>
<tr>
<th>Properties and names</th>
<th>α</th>
<th>β</th>
<th>γ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtypes</td>
<td>αA, αB</td>
<td>β_L, β_H</td>
<td>γ_A, γ_B, γ_C, γ_D, γ_E, γ_F</td>
</tr>
<tr>
<td>Primary structure</td>
<td>N-terminus</td>
<td>N-terminus</td>
<td>N-terminus not</td>
</tr>
<tr>
<td></td>
<td>acetylated.</td>
<td>acetylated.</td>
<td>acetylated.</td>
</tr>
<tr>
<td></td>
<td>Sequence</td>
<td>Sequence</td>
<td>Sequence</td>
</tr>
<tr>
<td></td>
<td>varies and</td>
<td>varies and</td>
<td>varies with</td>
</tr>
<tr>
<td></td>
<td>is modified.</td>
<td>is modified.</td>
<td>subtype.</td>
</tr>
<tr>
<td>Secondary structure</td>
<td>α-helical and</td>
<td>β-pleated</td>
<td>β-pleated</td>
</tr>
<tr>
<td></td>
<td>β-pleated</td>
<td>sheets.</td>
<td>sheets.</td>
</tr>
<tr>
<td></td>
<td>sheets.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary structure</td>
<td>Possibly</td>
<td>Probably</td>
<td>Globular</td>
</tr>
<tr>
<td></td>
<td>globular.</td>
<td>globular.</td>
<td></td>
</tr>
<tr>
<td>Quaternary structure</td>
<td>Uncertain,</td>
<td>Large globe of</td>
<td>None, it has a</td>
</tr>
<tr>
<td></td>
<td>consists of</td>
<td>polypeptides</td>
<td>single polypeptide.</td>
</tr>
<tr>
<td></td>
<td>nascent and</td>
<td>with a range</td>
<td></td>
</tr>
<tr>
<td></td>
<td>modified</td>
<td>of 23,000–35,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>polypeptides</td>
<td>daltons each.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>each 20,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>daltons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molecular weight</td>
<td>750,000</td>
<td>50,000 (β_L) and</td>
<td>20,000</td>
</tr>
<tr>
<td>(daltons)</td>
<td></td>
<td>160,000 (β_H)</td>
<td></td>
</tr>
<tr>
<td>Cysteine content</td>
<td>16 per 1000</td>
<td>25 per 1000</td>
<td>41 per 1000</td>
</tr>
<tr>
<td></td>
<td>residues</td>
<td>residues</td>
<td>residues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pl</td>
<td>~4.9</td>
<td>~6.4</td>
<td>~7.6</td>
</tr>
<tr>
<td>Relative lens</td>
<td>~35%</td>
<td>~55%</td>
<td>~10%</td>
</tr>
<tr>
<td>occurrence</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1- post-translational modification
2- some α-helix ?
3- β-sheet
4- actual M_wt in dispute
5- based on avg M_wt of 125
6- also based on avg M_wt of 125
7- pl = pH at which all (+) and (-) charges are equal
8- % of crystallins in the whole lens – only α-crystallins are in the lens epithelium
Post-translational modifications to proteins (including crystallins)

- **Acetylation** (addition of CH$_3$-C-O$^-$) on N-terminus on α and β crystallins, protects from protein degradation.

- **Phosphorylation** (addition of O-P-O$_3^{2-}$ on Serines on α crystallins)
  - Adds negative charges to each change; could change structure.

- **Glycosylation** (addition of sugar groups) on Serines on α and β (?) crystallins.

- **Deamidation** (conversion of Asn to Asp and Gln to Glu) on α and β (?) crystallins. Could be part of aging process.

- **Oxidation** (conversion of –SH to S-S disulfide or –S-CH$_3$ to –S-CH$_3$ on α and β crystallins, could be aging process.
The simplest crystallins are members of the $\gamma$ group. They consist of two sets of beta pleated sheets joined by a connecting peptide (at lower right).

The $\beta$-crystallins consist of at least four sets of beta pleated sheets in which there are two n-terminal ends and two c-terminal ends; there are two polypeptide chains. The proteins appear to be complex forms of $\gamma$-crystallins (see lower left structure).

The $\alpha$-crystallins have an unknown structure. One proposed structure is shown. This cartoon is meant to demonstrate a possible way that these crystallins might be able to function as protein chaperones. They literally guide molecules into their interior and re-fold them.
An example of an experiment that demonstrates chaperone activity in α-crystallins; the denaturation of β-crystallins is shown by light scattering. Adding α-crystallin to a β-crystallin solution prevents denaturation of the β-crystallin.
What do the crystallins do for the lens?

- When you look at the lens, it should be reasonably obvious that the lens fiber cells are wrapped around the lens at larger and larger diameters.

- The fiber cells are stretched out thin and meet each other at their ends.

- The integrity of these cells depends on a substantial cytoplasm.

FIG. 10-8 Scanning electron micrograph showing the characteristic hexagonal cross sectional profiles of vertebrate lens fiber cells. (Courtesy J. Kuszak.)
Evolution suggests that the lens crystallins are an adaptation toward a passive role in which these proteins allow a plastic shape for the lens fiber cells and impart a degree of strength to the cell itself.

After a lens fiber cell is formed from a lens epithelial cell, it loses all of its protein generating “machinery” and the cell slowly loses water content with age.

The cell starts out with about 15% protein and eventually winds up with about 90% protein as it is buried deeper and deeper in the lens – the cell depends upon its crystallin content to maintain shape and integrity.
What happens to the lens as it ages?

One of the 1st pieces of data to be collected with an ageing lens showed an increase in protein with age – particularly with a cataractous lens.

What could it mean?

What is the insoluble fraction?
Other data:

1) Post-translational modifications of proteins seemed to promote cataract formation (with age)

2) Hydrogen peroxide (H$_2$O$_2$) is present in the aqueous and causes oxidation.

3) The lens is subject to UV radiation, which produces free radicals.

On the other hand –

1) There was the chaperone activity of $\alpha$-crystallin
2) There was the anti-oxidative activity of glutathione.
3) There was a high concentration of Vitamin C (ascorbate) in the aqueous.

So there are competitive effects found in the ageing lens that may Both promote and protect from cataract formation.
What are the damaging effects?

Post-translational modification and other effects include-

A) phosphorylation may weaken the chaperone properties of \( \alpha \)-crystallins by opening its structure (negative charges of phosphate groups)

B) phosphorylation may make all crystallins subject to oxidation (disulfide bond formation) and the beginning of protein complex formation

C) free radicals are atoms with unpaired electrons that readily react with proteins and lipids

D) hydrogen peroxide causes similar effects on proteins and lipids
What are the protective effects?

a) Chaperone effects of α-crystallin you already know about

b) The protective effects of glutathione are to prevent oxidation (transfer of electrons) and neutralize hydrogen peroxide.
Oxidation of crystallin.

By reacting with an "exposed" SH group on crystallin, glutathione prevents a 2nd molecule of crystallin from binding and, therefore, delays crystallin aggregate formation.
Why is it important to prevent crystallin oxidation?

When the crystallin conformation is opened up (i.e., phosphorylation)
It is possible for the –SH groups in Cys to react with one another to form disulfide bonds

If the process continues then aggregate (precipitate) formation occurs and may lead to cataract formation.

The formation of these high molecular aggregates do occur in the lens – some are found in cataracts

(see figure 2-16 in text)
CATARACTS

A cataract (Greek: καταρακτεσ.. something fallen down) is a loss of transparency in the lens or even the lens capsule.

Cataract formation may be gradual or sudden with opacities in both the nucleus (inner region) and/or the cortex (outer region) of the lens. It is often noticed as a glare in the eyes with oncoming headlights of another car at night.

Senile cataracts (vs. chemical, diabetic and hereditary types) are considered to be age related.
There are many variations on the forms and colors of cataracts. These are typical senile cataracts.
BIOCHEMICAL EVENTS
ASSOCIATED WITH
SENILE CATARACT FORMATION

The exact cause(s) of senile cataract formation (as with many diseases) are not known with certitude. However, years of research has pointed to relevant events that can be associated with the formation of senile cataracts.

Senile cataract formation is manifested by the formation of white opacities in the cortex (cortical cataract) and/ or the formation of a yellow to dark brown color in the nucleus (nuclear cataract). Cortical cataracts also involve the destruction of lens fiber cells.

Senile cataract formation is a gradual process that is thought to occur by both oxidative and UV radiation events in the lens. For reasons not understood, some individuals are better able to withstand these destructive events than others. This may be due, in part, to variations in protective or resistive processes present in all lens tissues. However, no hereditary trends have been established for the competition of protective and destructive trends in this form of cataract.
REVIEW OF AGEING EVENTS IN THE LENS

1) POST-TRANSLATIONAL EVENTS IN THE CRYSTALLINS:
   - PHOSPHORYLATION
   - DEAMIDATION
   - OXIDATION

   ALL OF THESE EVENTS ARE CONCERNED WITH OPENING UP THE CRYSTALLIN STRUCTURE AND CAUSING CROSSLINKING OR AGGREGATION OF THE PROTEINS

2) “YELLOWING” OF THE LENS

3) INCREASE IN INSOLUBLE PROTEIN RELATED TO 1) ABOVE

AT THIS POINT ONE MAY ASK: IS CATARACT FORMATION SIMPLY A RESULT OF A PREPONDERENCE OR EXCESS OF THE AGEING EVENTS THAT OUTWAY THE PROTECTIVE EVENTS?
A MECHANISM FOR CATARACT FORMATION

A
AGGREGATION

C
CELLULAR
DEBRIS

B
RUPTURE

DEBRIS FORMATION

MEMBRANE
RUPTURE
Notes: (from previous figure)

1) 26k = a 26kd intrinsic membrane protein that binds to crystallin aggregates.

2) 43k = a 43kd extrinsic membrane protein that binds to Crystallin aggregates.

3) Contrary to what is stated in the text, this seems to Be a mechanism only for cortical cataract formation.

4) The cellular debris represents what is seen as the white material of a cortical cataract
NUCLEAR CATARACTS AND THE PROBLEM OF UNDERSTANDING HOW THEY ARE FORMED.

Nuclear cataracts are more difficult for the patient since they both scatter light and absorb light causing an increased disruption in vision.

Nuclear cataracts and lens yellowing have often been related to one another, but the process in which they are formed remains unknown.

Related to this process is the fact that a secondary important role of the lens is to act as a filtering device to prevent UV radiation between 295 and 400 nm from reaching the retina. Such radiation would destroy the retina very quickly.