**Lens Proteins** constitute what proportion of the lens by weight?
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Um, cool story bro. Is that proportion supposed to be impressive?
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Alrighty then. Is it impressively high, or low?
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Alrighty then. Is it impressively high, or low?
High—no other tissue comes close (a content-by-weight of a third is **2 to 3 times** the protein content of most other tissues!)
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Briefly, what is the ‘life cycle’ of a lens fiber?

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But first, consider the primary purpose of the lens: **Focusing incoming light on the fovea**.

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But first, consider the primary purpose of the lens: **Focusing incoming light on the fovea**. To do this, the lens must supply **20D** (aka **converging** power). Of the roughly **60D** of converging power possessed by the typical eye, **20D** are supplied by the lens (the other **40D** being supplied by the **cornea**).

Here's where Snell's law comes into play. Snell's law tells us that the dioptric power produced at a refracting surface is

\[
P = \frac{n'}{n} \cdot \frac{1}{r}
\]

where
- \(n'\) is the refractive index of the substance the light is heading into (the lens in this case),
- \(n\) is the refractive index of the substance the light is coming from (the aqueous), and
- \(r\) is the *radius of curvature of the refracting surface (the anterior lens capsule)*.

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Lens Proteins

OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values.

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You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there.
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By way of an example, consider: Why is underwater vision so blurry? The refractive index of the cornea is about 1.34, and the refractive index of air is 1.0, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the refractive index of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero. This means that essentially no refraction takes place at the cornea underwater, effectively eliminating 40 of the 60D of convergence needed for clear vision. This is how the numerator in Snell’s law transforms an on-land emmetrope into an underwater hyperope (and a very high one at that).

But to consider it another way, the high protein concentration of lens fibers is not just a function of keeping the lens from becoming too soft and losing its ability to refract light. It is directly related to the high protein content of lens fibers, which is needed to produce the refractive index of the lens that renders it an effective refracting structure. We will unpack this statement over the next several slides, but doing so requires we take a couple of steps back and review 1) lens-fiber development; and 2) Snell’s law of refraction.
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Before we move on:

---If you’re not grocking this whole Snell’s law thing, review slide-set BO17 (or better still, do the whole Basic Optics tutorial)

---For more details concerning lens fiber development, see set L14
Lens proteins come in one of two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
Lens proteins come in one of two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
One of these types predominates in the lens of a young person— which one?
One of these types predominates in the lens of a young person—
which one?
Water soluble
One of these types predominates in the lens of a young person— which one?
Water soluble

Water-soluble proteins comprise what percentage of proteins in the young lens?
Lens Proteins

Water Soluble

Water-soluble proteins comprise what percentage of proteins in the young lens?
80%

One of these types predominates in the lens of a young person— which one?
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Water soluble

What happens to the relative proportions of water soluble vs insoluble proteins as the person ages?
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What happens to the relative proportions of water soluble vs insoluble proteins as the person ages?
It reverses—water insoluble predominates
One of these types predominates in the lens of a young person—water soluble or water insoluble? What happens to the relative proportions of water soluble vs insoluble proteins as the person ages? It reverses—water insoluble predominates.

What accounts for this change in the proportion of water-soluble vs insoluble proteins? It's very straightforward—as the lens ages, water-soluble proteins aggregate, in the process forming particles that are water-insoluble.

Is this fact of any clinical relevance, or are you just torturing me with minutiae? Unlike much of the esoterica in this slide-set, a straight line can be drawn from this fact to the exam room. These water-insoluble aggregates are very large and scatter light, thereby reducing acuity. Further, there is a direct correlation between the proportion of water-insoluble proteins and how brunescent a cataract is.
Lens Proteins

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Water-insoluble proteins comprise what percentage of proteins in an old, brunescent lens?

It can be as high as 90%!
One of these types predominates in the lens of a young person—which one? Water soluble.

What happens to the relative proportions of water soluble vs insoluble proteins as the person ages? It reverses—water insoluble predominates.

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By what other name are the water-soluble proteins known?
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Crystallins come in three forms (two of which are grouped together). What are they?
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What might you be expected to remember about each of the crystallins?

- α: The largest
- β, γ: Smallest
By what other name are the water-soluble proteins known?

'Crystallins'

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Lens Proteins

Water Soluble aka...

Crystallins

α

βγ

Water Insoluble

What might you be expected to remember about each of the crystallins?
α: The largest; also, it is a heat-shock protein
β
γ
By what other name are the water-soluble proteins known?

'Crystallins'

Crystallins come in three forms (two of which are grouped together). What are they?

What vital role do crystallins play in lens function?

They are the proteins cranked out by elongating lens fibers that increase the lens’s refractive index enough to render it a viable refracting structure.

What might you be expected to remember about each of the crystallins?

α: The largest; also, it is a heat-shock protein

βγ

In general, what is a heat-shock protein?

A protein expressed in response to stress

What role does α-crystallin play in the lens in this regard?

Denatured lens proteins will aggregate (ie, glom together) to form large particles; α-crystallin interdicts this process by binding to the denatured proteins
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β, γ: aka Crystallins

Water Soluble

Water Insoluble

Lens Proteins

α

β γ

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Is protein denaturation and aggregation a significant issue in the human lens?
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**Lens Proteins**

**Q/A**

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Is protein denaturation and aggregation a significant issue in the human lens?

Indeed it is. The resulting particles contribute directly to cataract formation.
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Lens Proteins

Water Soluble aka… Water Insoluble

Crystallins

α

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Lens Proteins

Water Soluble

aka...

Water Insoluble

Crystallins

α

βγ

α: The largest; also, it is a heat-shock protein
β: The most common by weight
γ: The smallest of the three
Water-insoluble proteins come two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
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What sort of protein comprises the majority of the urea-soluble fraction of the water-insoluble lens proteins?
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What function do cytoskeletal proteins serve?
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What function do cytoskeletal proteins serve?
They are the primary component of the structural framework of lens cells
What sort of protein comprises the majority of the urea-insoluble fraction of the water-insoluble lens proteins?
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Major intrinsic protein (MIP)
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For what function are aquaporins known?

As water channels in cell membranes (Note: The Lens book is not clear whether the MIP/aquaporin in lens cells serves this function)
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Neuromyelitis optica (NMO, aka Devic’s dz) and neuromyelitis optica spectrum disorder (NMOSD)

Which aquaporin is implicated in these conditions?

Aquaporin 4 (AQP4)

What is the typical ophthalmic manifestation of NMO(SD)?

Optic neuritis
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Aquaporin 0

Is AQP4 the aquaporin found in the lens?

No

Which aquaporin is found in lens cells?

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For more on AQP4 and NMO(SD), see slide-set N8

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