

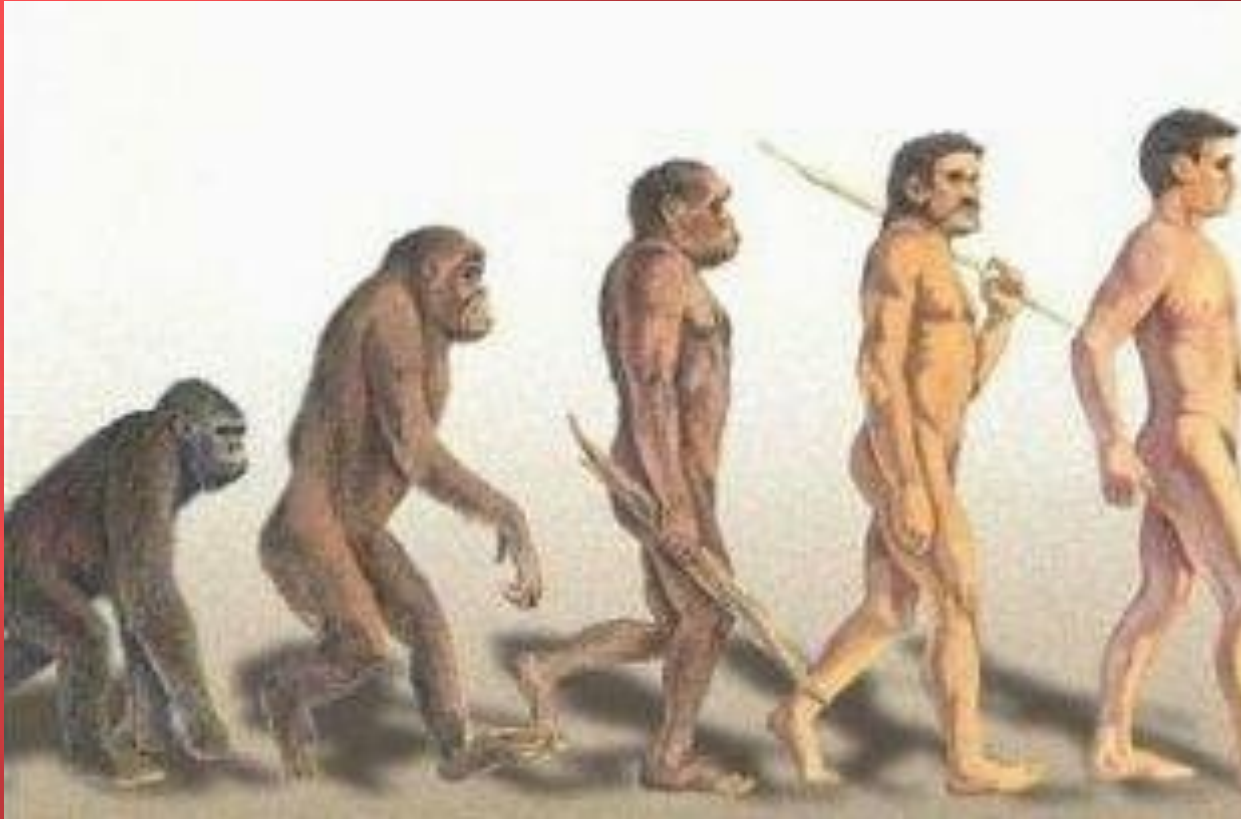
AN INTRODUCTION TO HAIR AND THE HAIR STRUCTURE

Trefor Evans, Ph.D

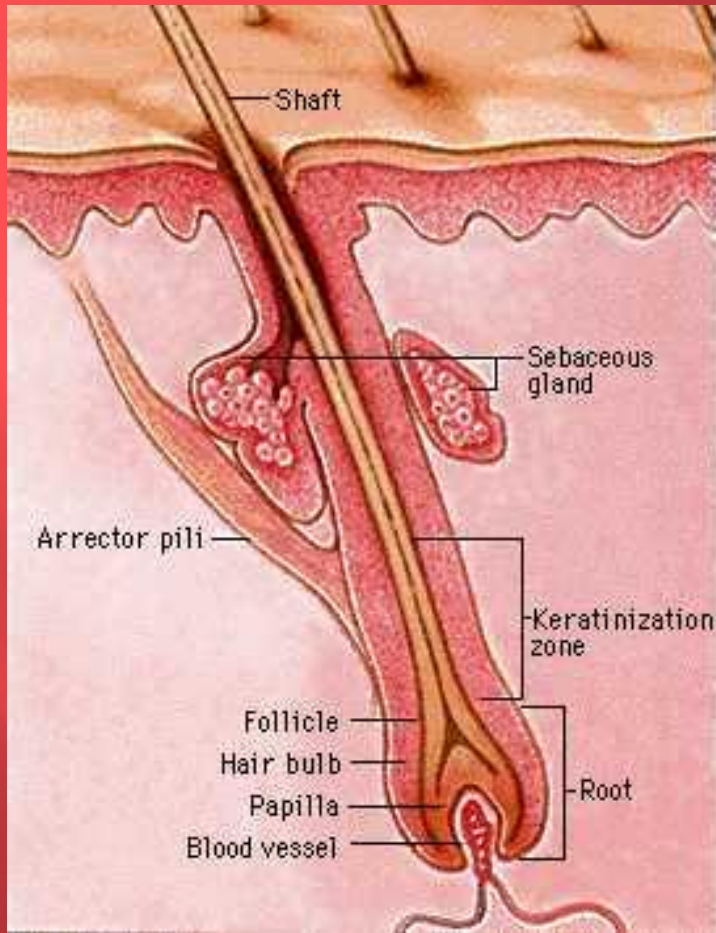
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Why do we have hair ?



Some general hair facts



Hair fibers grow out of follicles that cover the scalp.

On average typical head contain 100,000 – 150,000 fibers.

Hair grows at the bulb in the base of each follicle and is nourished by blood vessels.

Hair undergoes cross-linking in the “keratinization zone” and emerges onto the head in an inert (dead) form.



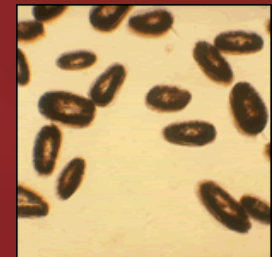
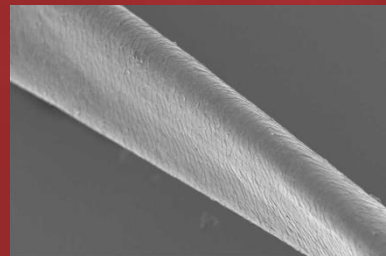
Hair comes in a bewildering variety of sizes, shapes, and colors



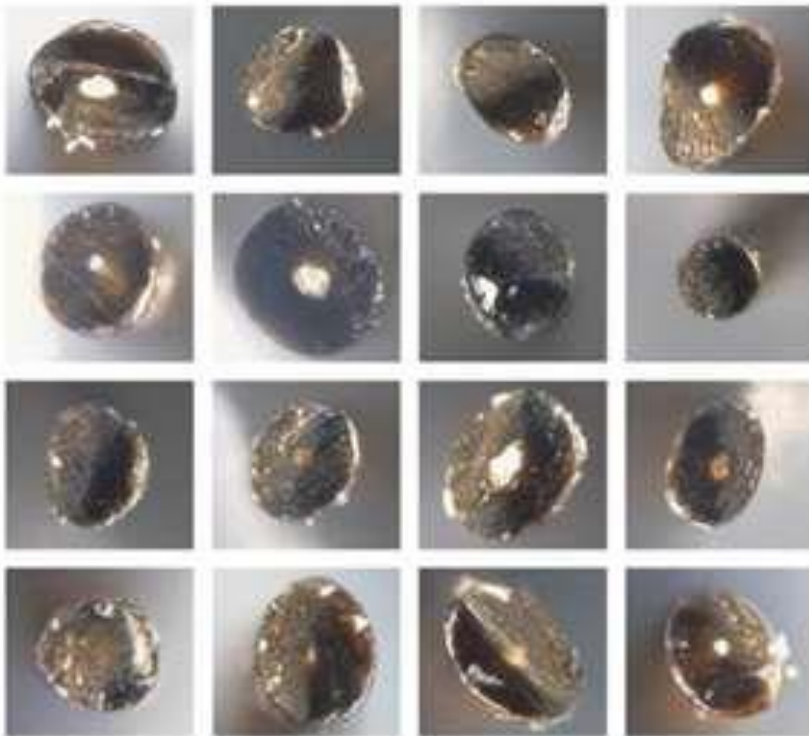
Hair comes in a bewildering variety of sizes, shapes and colors

Average diameter of hair is typically around 70 μm – although not unusual to find hair anywhere in the range $\approx 50\text{-}110 \mu\text{m}$.

Spherical, oval, ribbon-like.

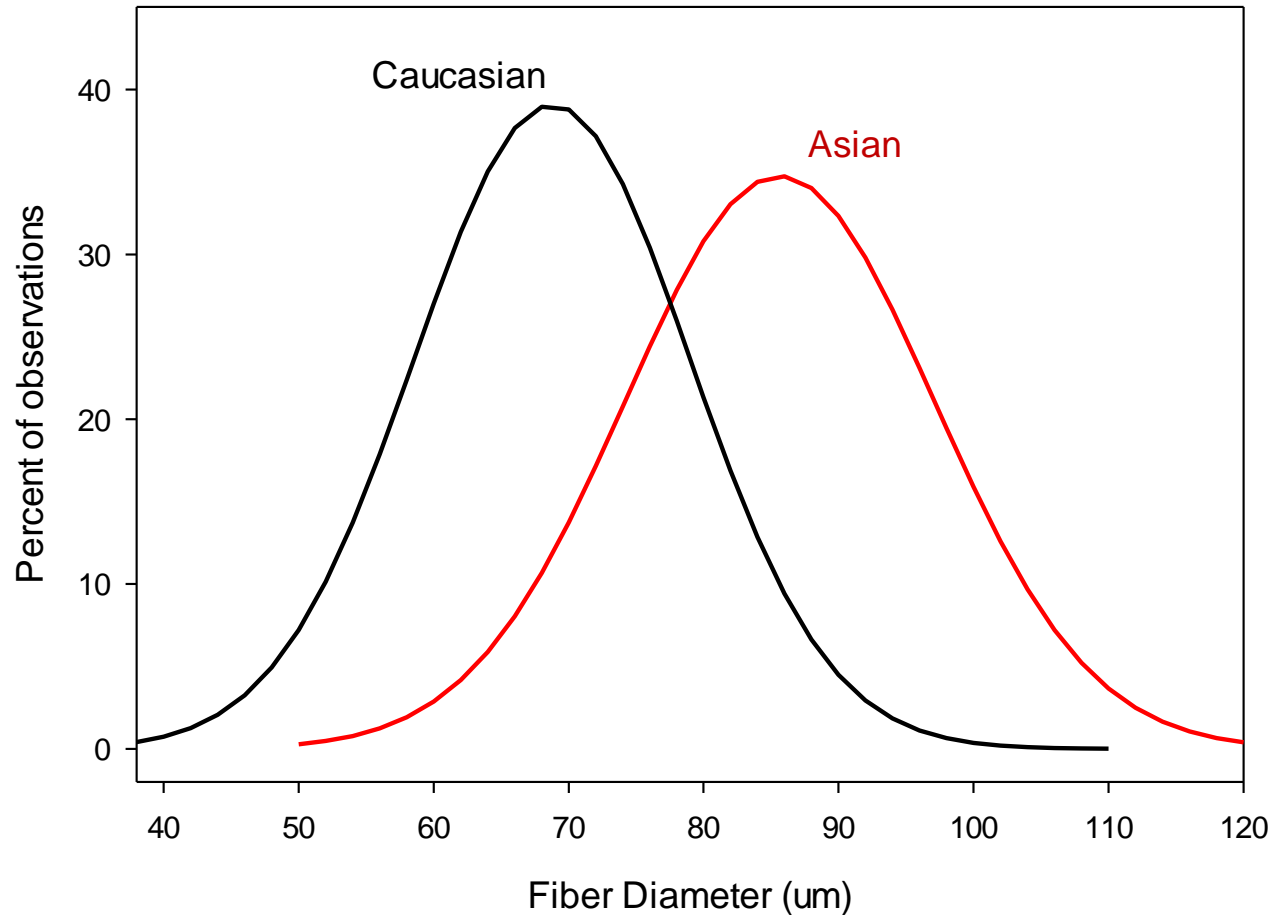


Hair grows at around $\frac{1}{2}$ inch per month.

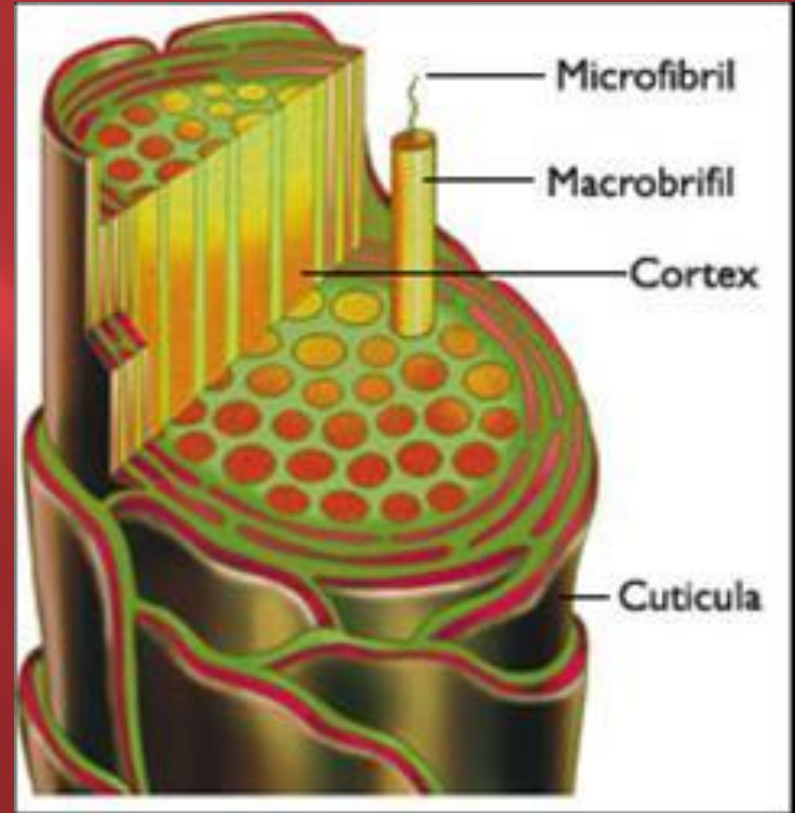
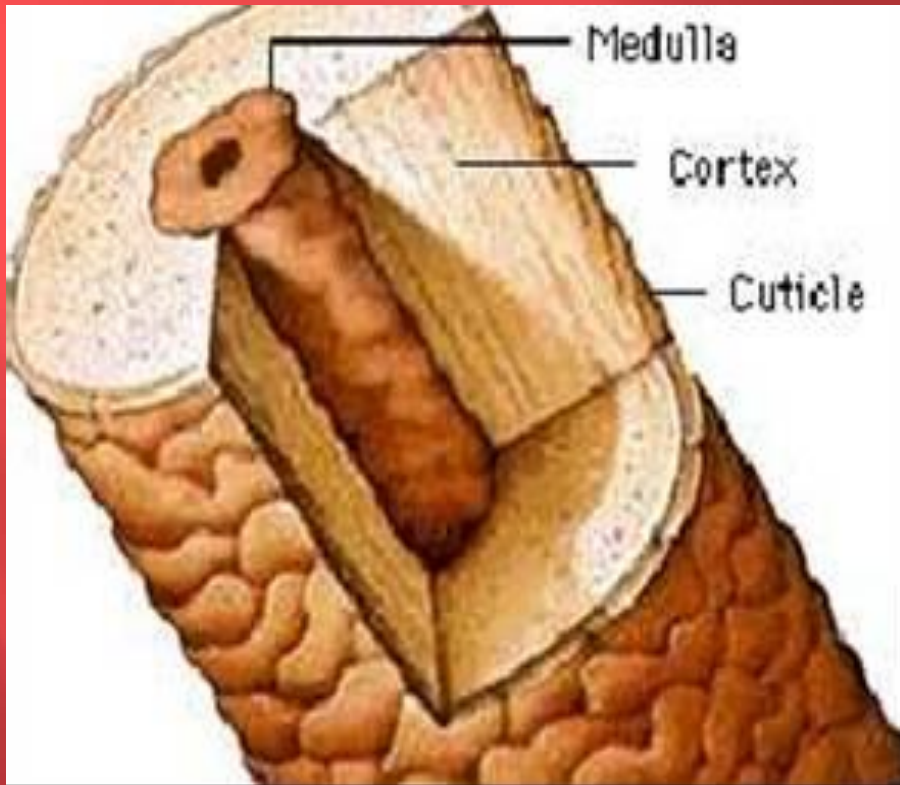


The broad distribution in fiber dimensions

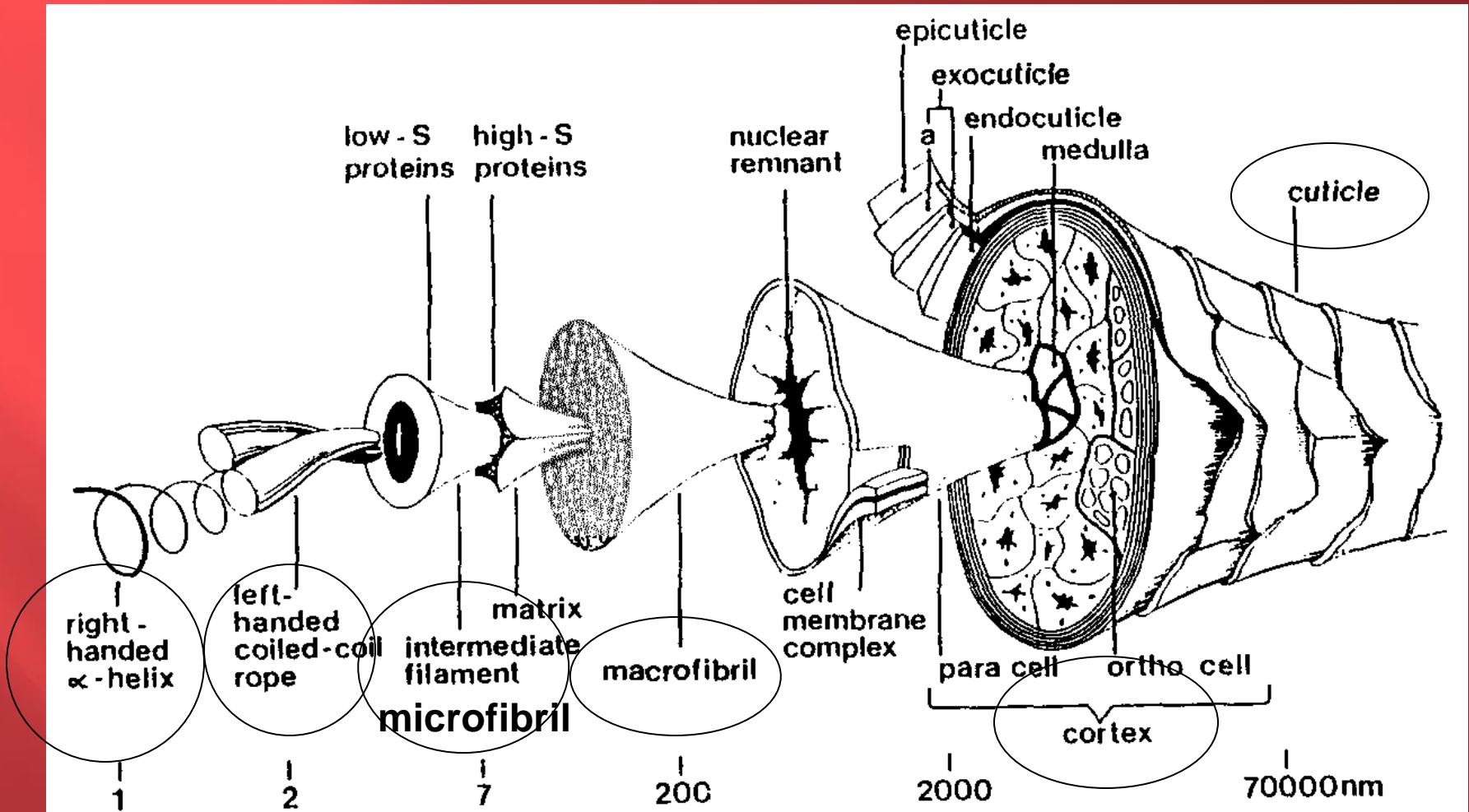
Histograms for fiber diameter as a function of hair type



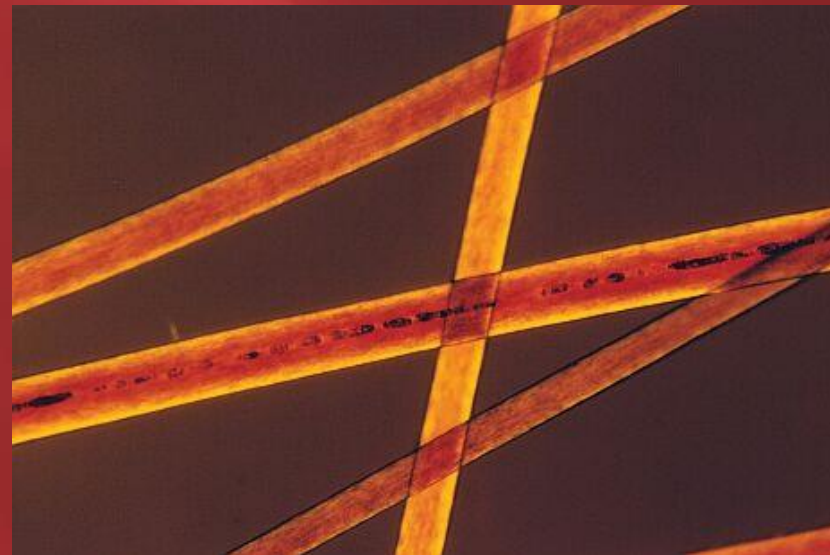
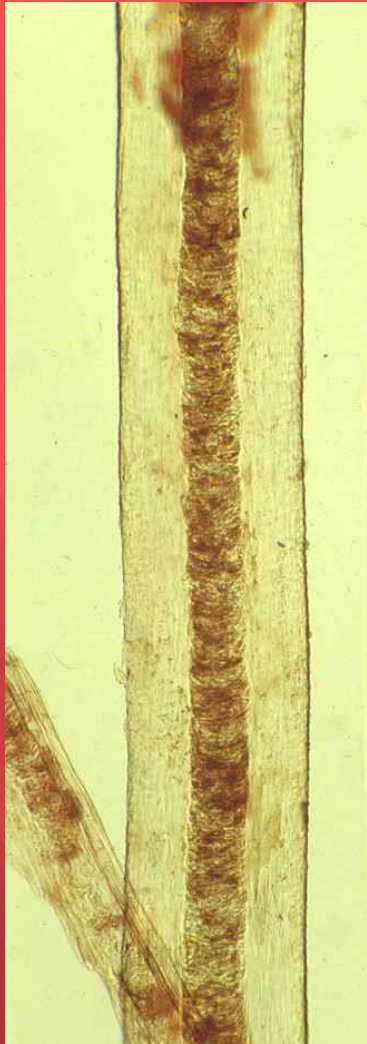
The Complex Structure of Hair



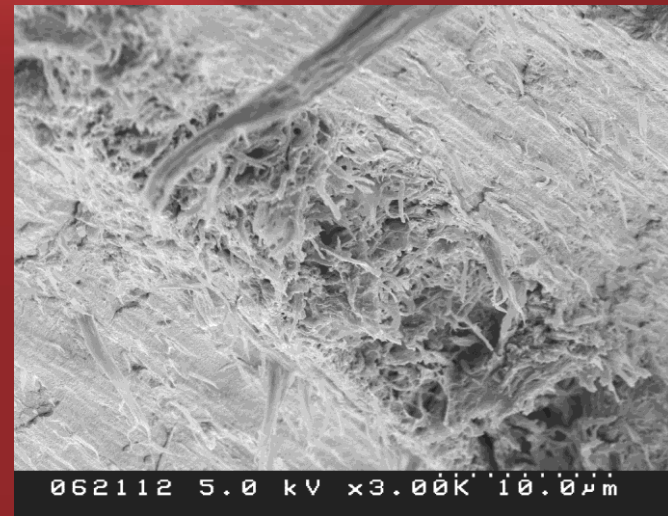
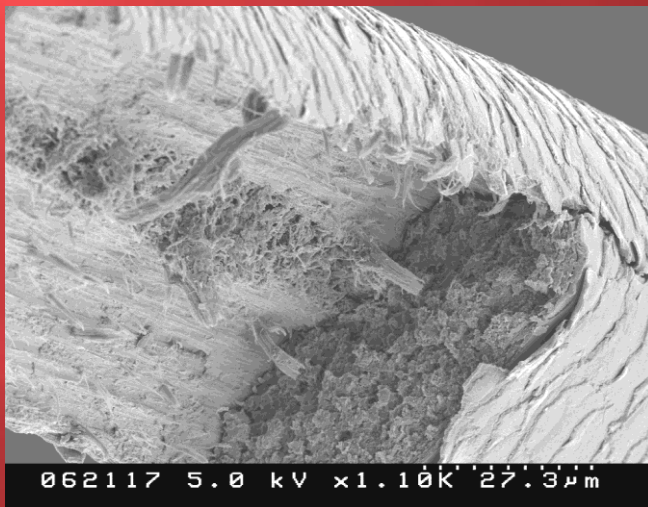
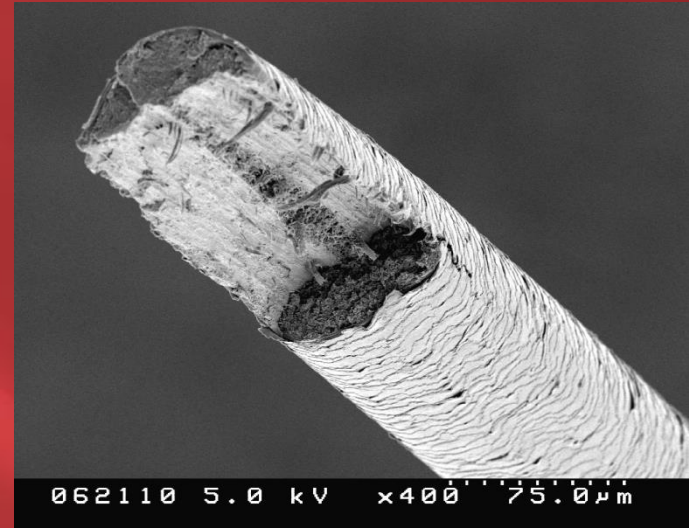
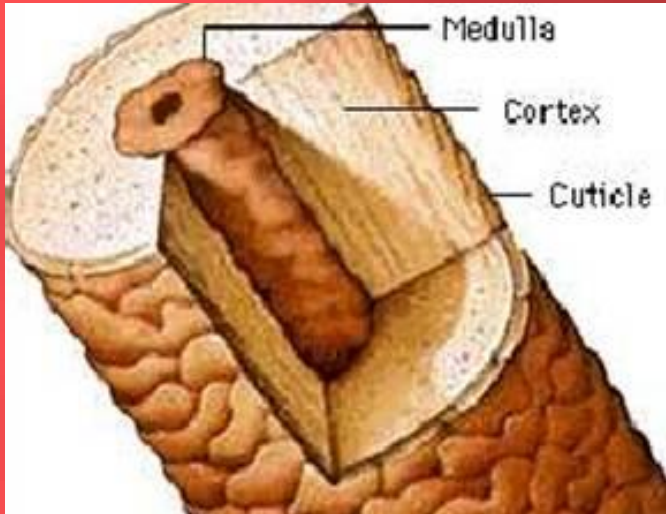
The Complex Structure of Hair



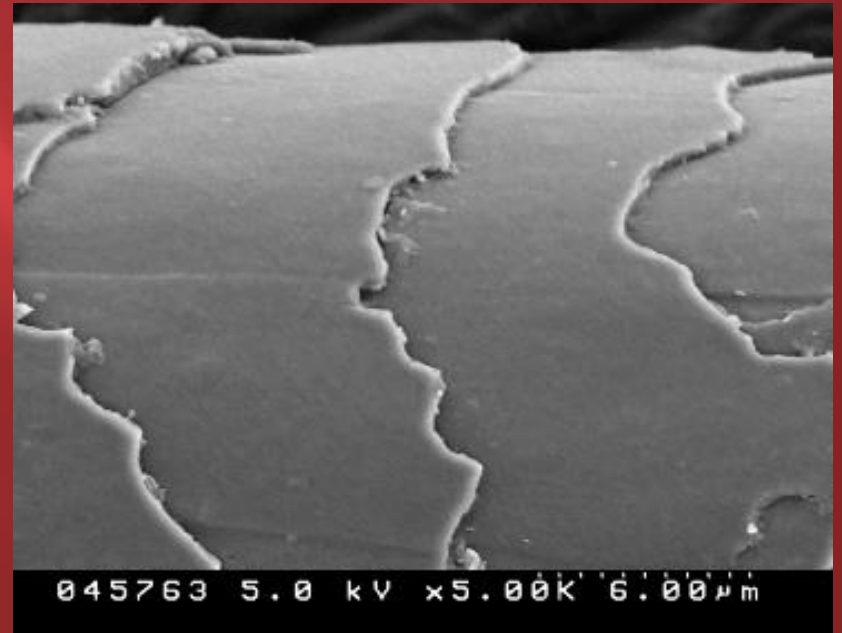
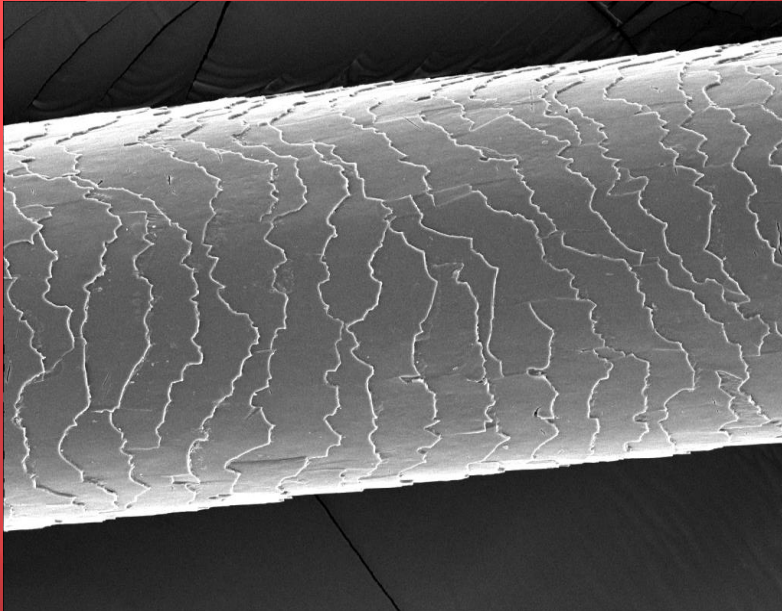
Light microscopy pictures



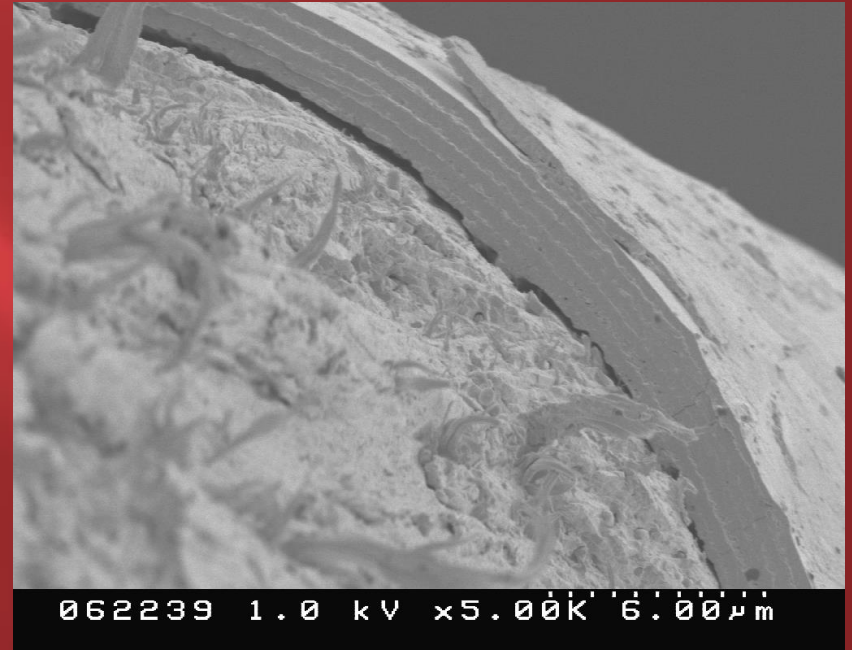
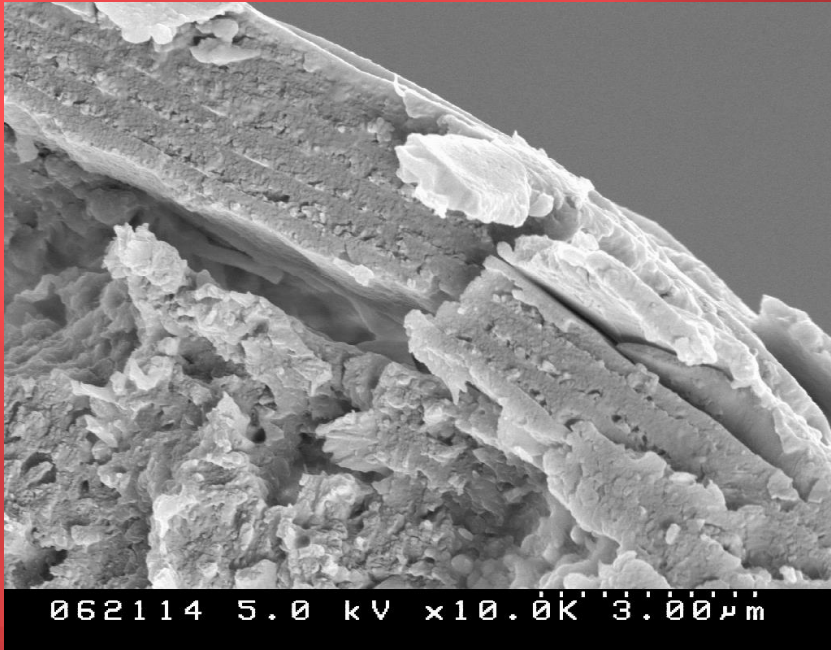
SEM Pictures of Hair



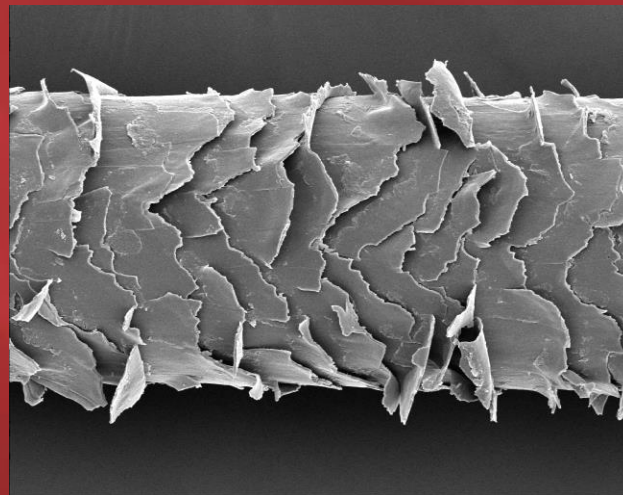
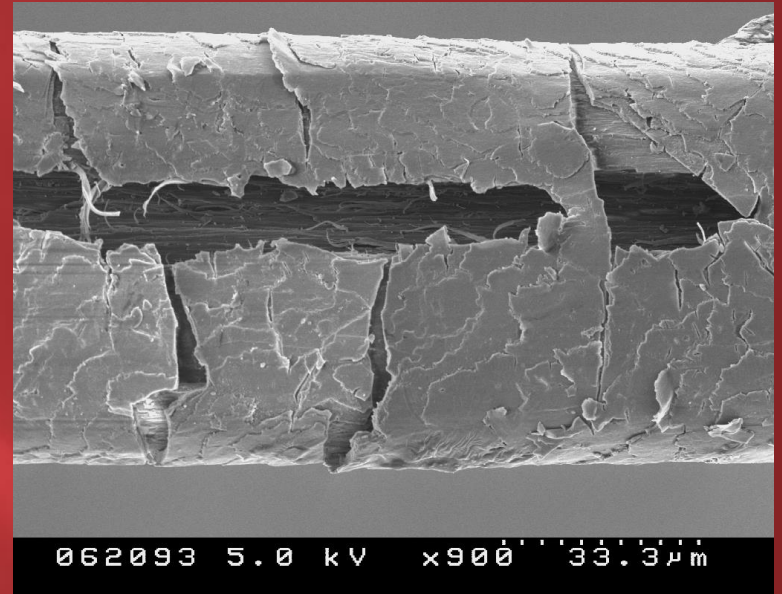
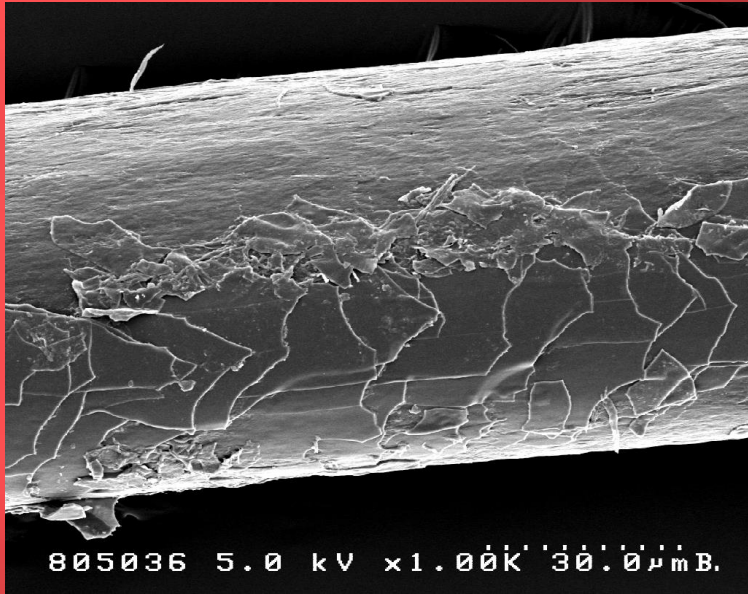
SEM Pictures of Hair



SEM Pictures of Hair



SEM Pictures of Hair



Cuticle myths – opening and closing



Eat your way to healthy hair



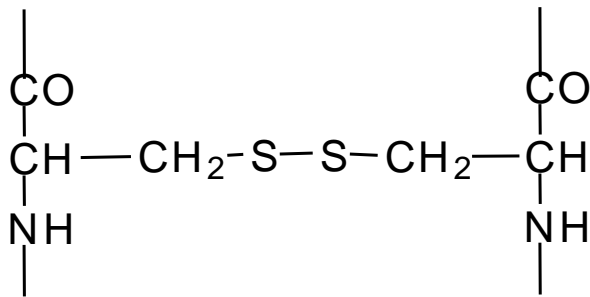
Protein

Hair's building block. It strengthens the hair shaft and reduces damage.

Keratin

Hair is composed of a specific protein - keratin

Keratin characterized by the presence of the amino acid, cystine

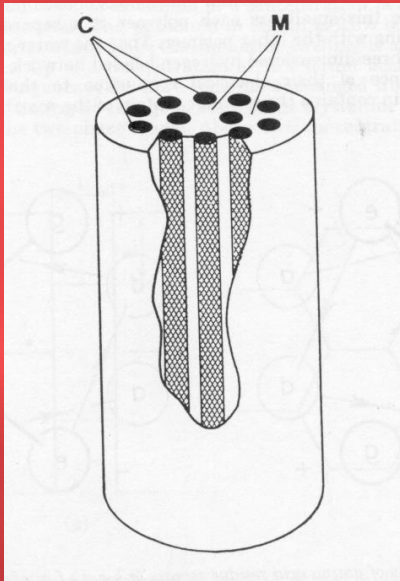


Keratin as a claims ingredient



Keratin

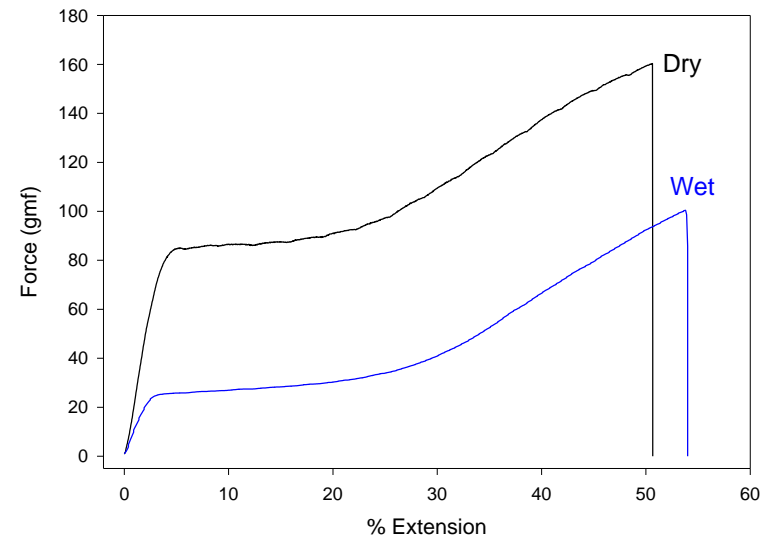
Macrofibril consists of crystalline α -helical keratin microfibrils embedded in amorphous keratin matrix.



Feughelman's 2-phase model

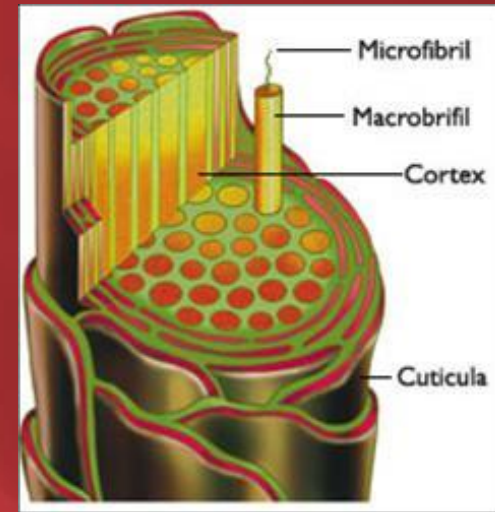
Textile Res.J., 29, (1959), 223-229.

Schematic stress-strain curves for wet and dry hair

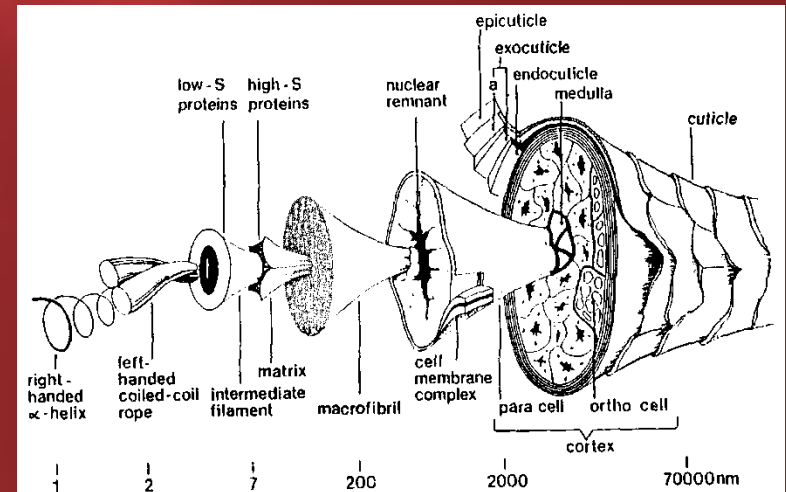


Cell Membrane Complex

It is estimated that the keratin components represent around 90% of the mass of a hair fiber. The remaining 10% of non-keratinous materials are often grouped together under the rather broad classification of lipids.



The Cell Membrane Complex: Three related but different cellular cohesion components of mammalian fibers – by Clarence Robbins, *Journal of Cosmetic Science*, Vol. 60(4), 2009, p437-465.



Lipids

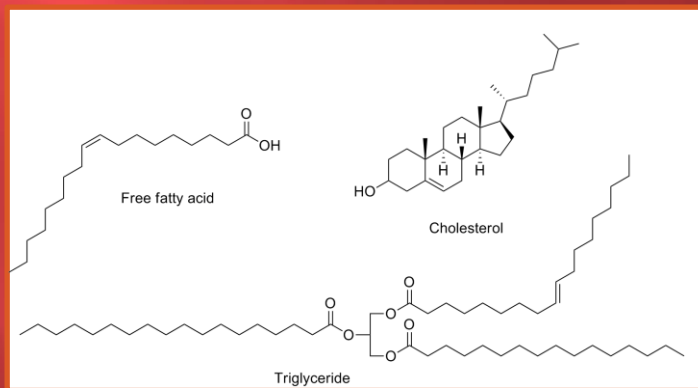
Lipid-like materials

Fatty acids
Cholesterol
hydrocarbons
Squalene
wax esters
triglycerides
ceramides.

Curry, K.V. and Golding, S., Hair lipids – I. The extraction of fatty materials from hair clippings, JSCC, 22, 681-699 (1971)

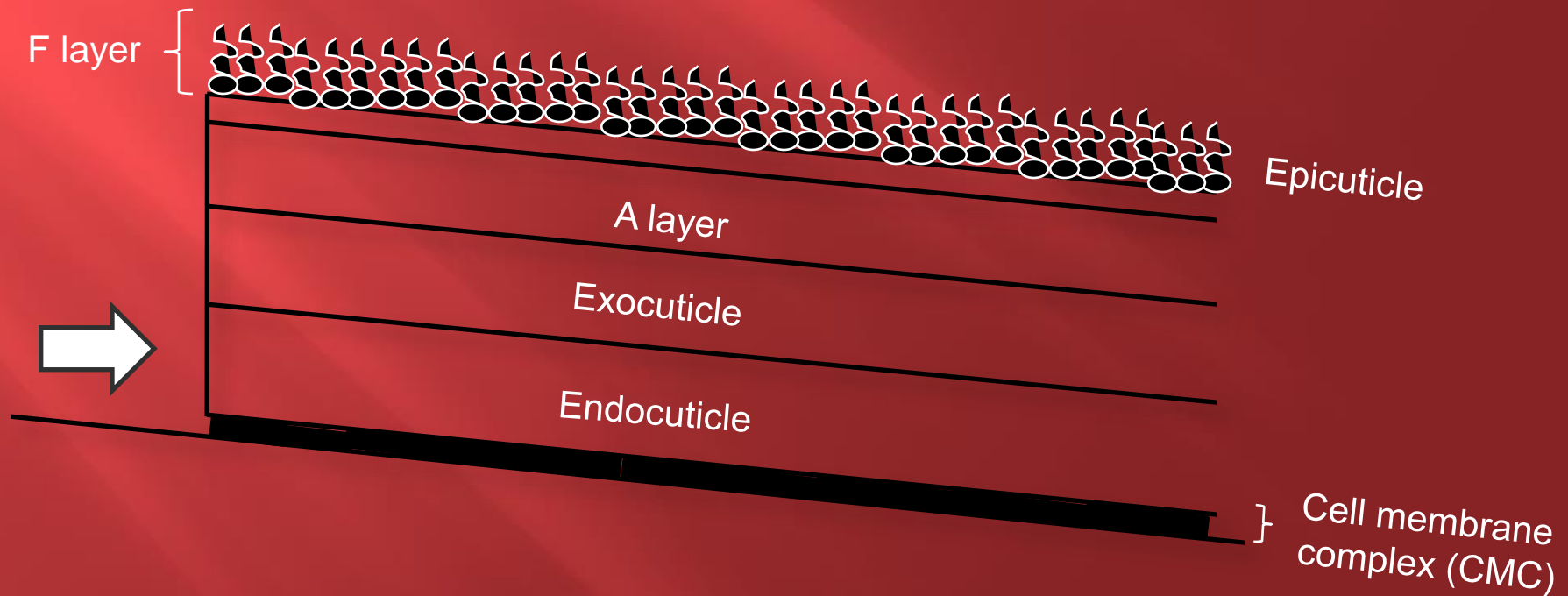
Masukawa et al., Characterization of the lipid composition at the proximal root regions of human hair. JSCC, 56, 1-16 (2005)

Masukawa & Tsujimura, Characterization of ceramides in human hair. Proc. 15th International Hair Science Symposium, 2007

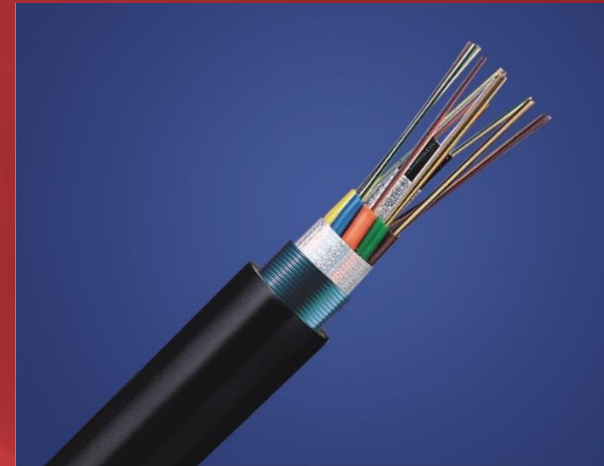
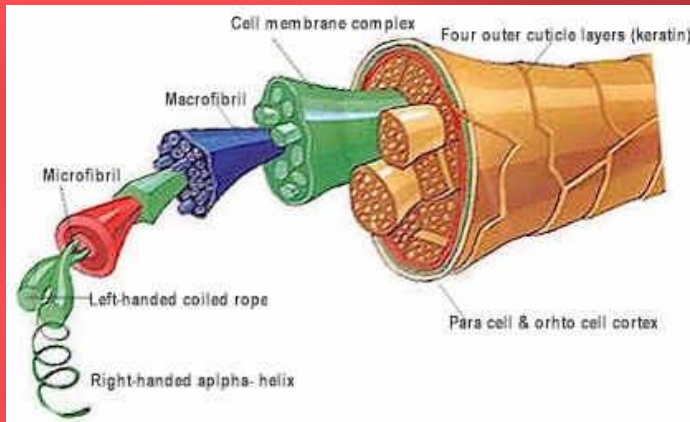


The cuticle structure

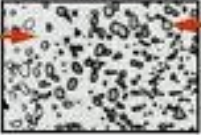

Epicuticle is $\approx 75\%$ heavily cross-linked protein covered by a lipid layer ($\approx 25\%$) which is predominantly 18 methyleicosanoic acid (18-MEA)



Hair is a complex bio-composite



Particle Reinforced Composites

Matrix: Ferrite (α - iron) Ductile		Particle: Fe_3C (cementite) Brittle
Matrix: Rubber (Compliant)		Particle: Carbon (Stiffer)

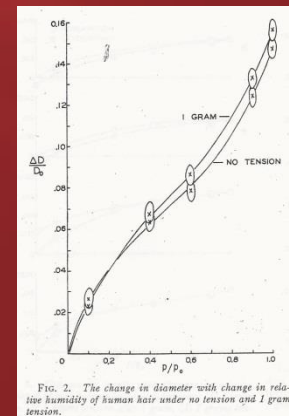
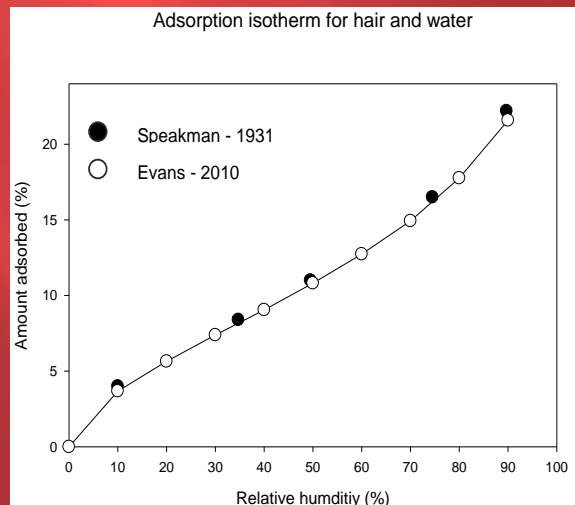
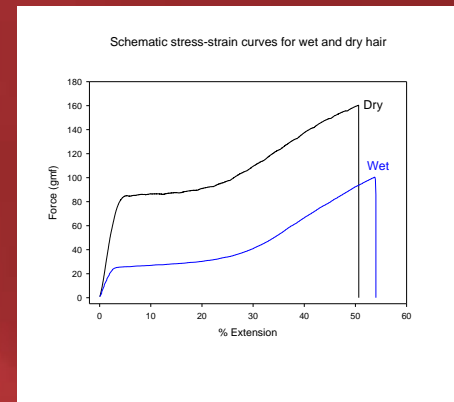
Automobile Tire

The effect of water on hair properties

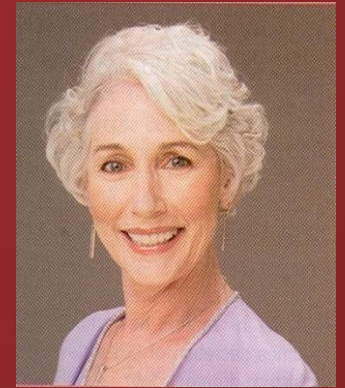
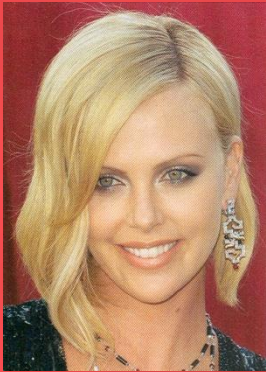
It has been suggested that water should be considered part of the hair structure due to the considerable effect it has on the properties.

The presence of water “plasticizes” the hair structure.

Water also causes hair to swell.



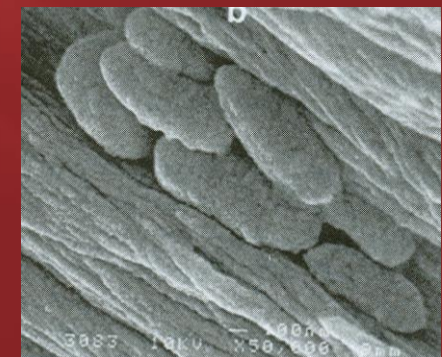
The Color of Hair



eumelanin

pheomelanin

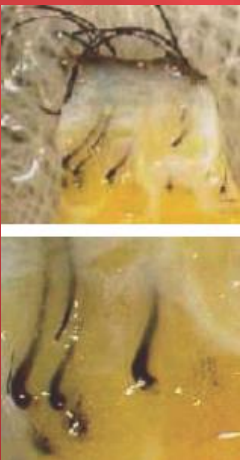
The natural color of hair is determined by its melanin content. The color is dictated by the amount and type of melanin present.



The Shape of Hair



The manner in which fibers grow out of the follicle is believed to dictate hair conformation.



Images taken from Thibaut, S., O. Gaillard, P. Bouhanna, D. W. Cannell and B. A. Bernard, Human hair shape is programmed from the bulb, *Br J Dermatol* 152(4): 632-638 (2005).

Hair Insults



Damaged

Hair repair



WOMEN'S
HAIR REPAIR
ADVANCED FORMULA

hair
repair

HAIR Repair



Winter
Hair
Repair

Dry Hair
Repair

NEW
ADVANCED HAIRCARE
TOTAL REPAIR 5
Damage-Erasing Balm

Repairing
damaged hair

damage remedy™
daily hair repair

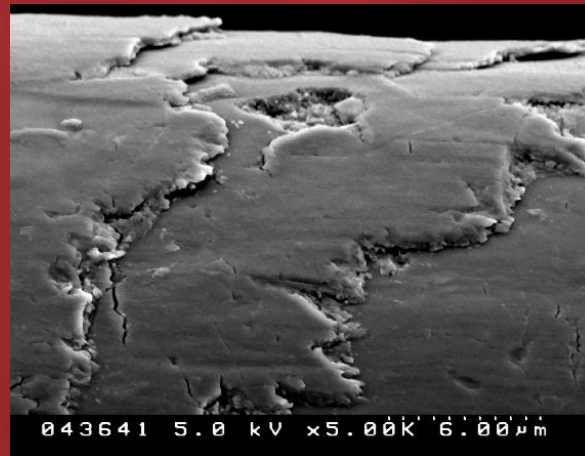
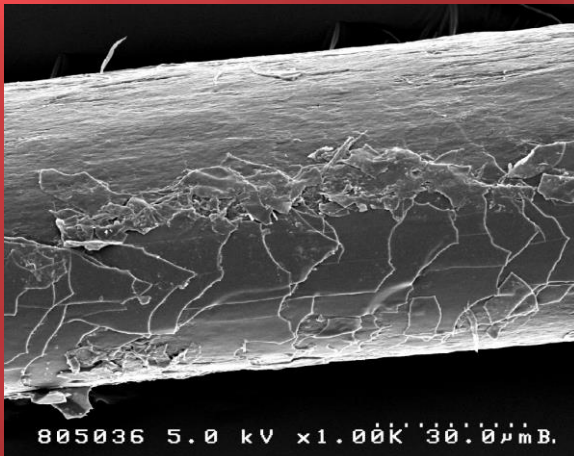
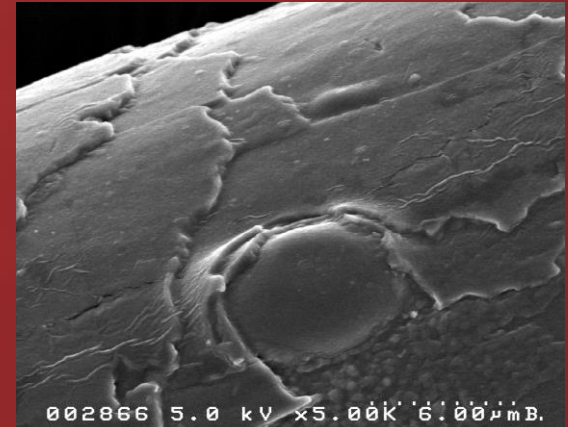
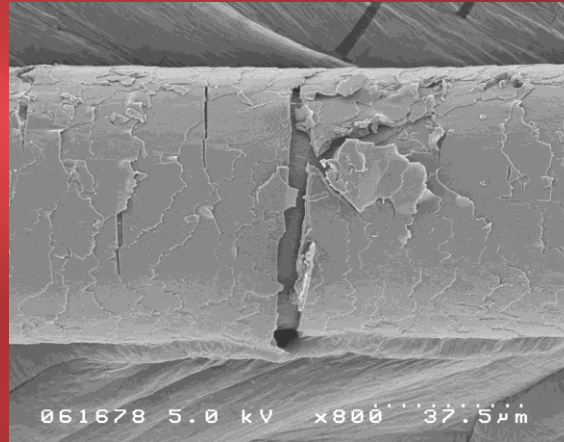
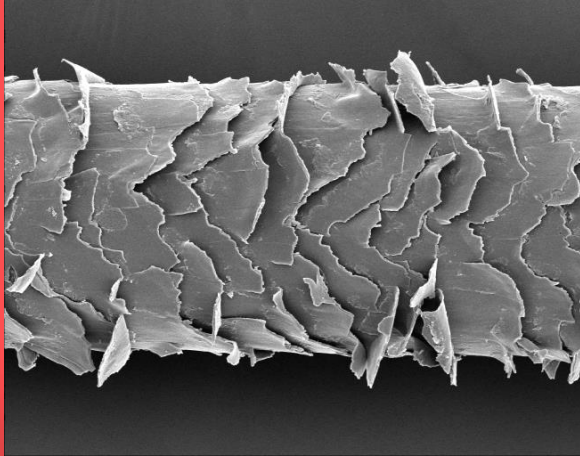


hair
repair

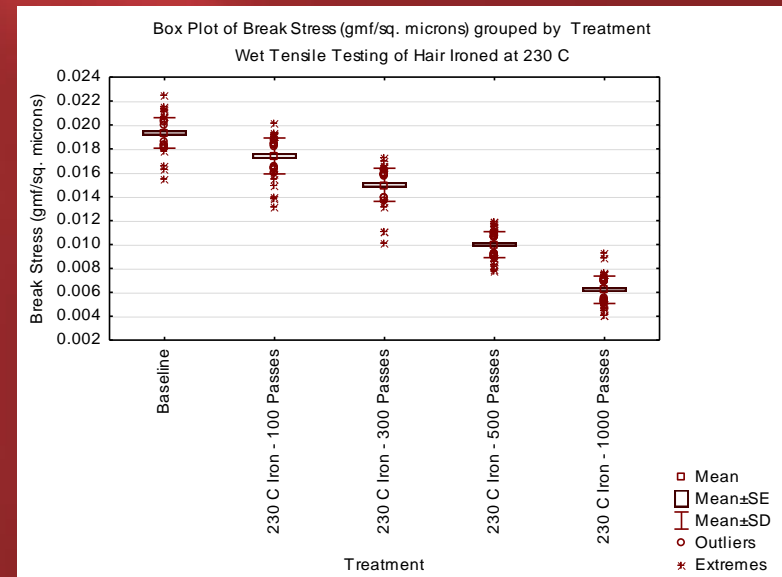
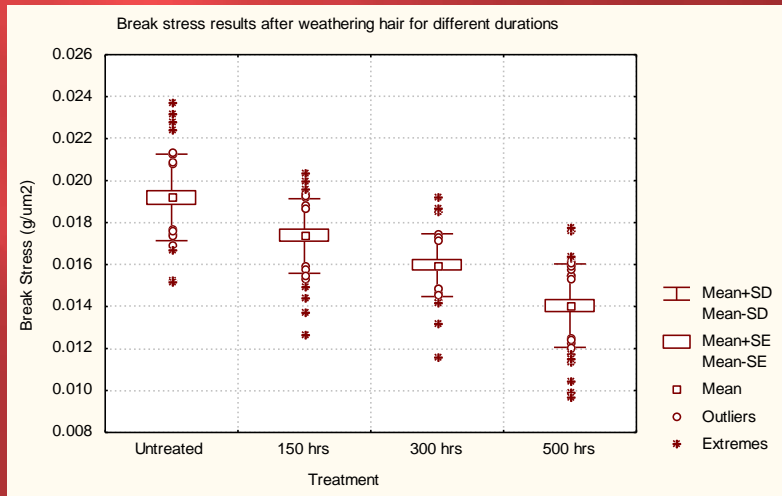
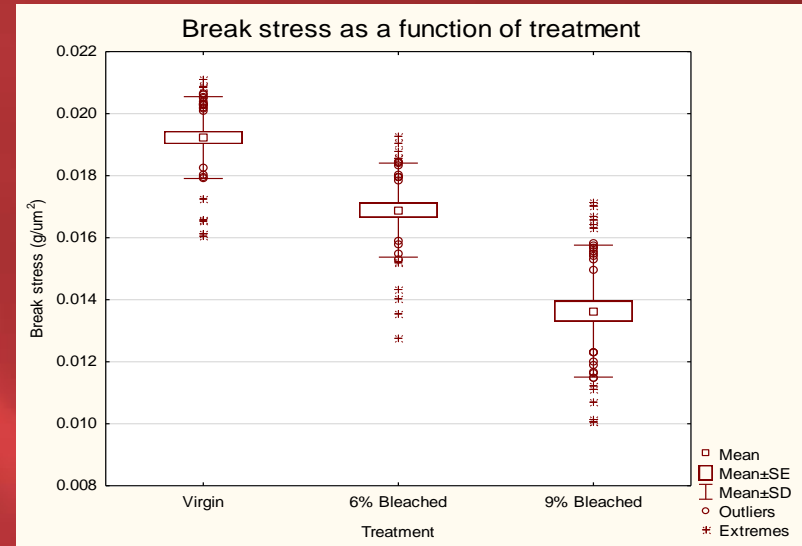
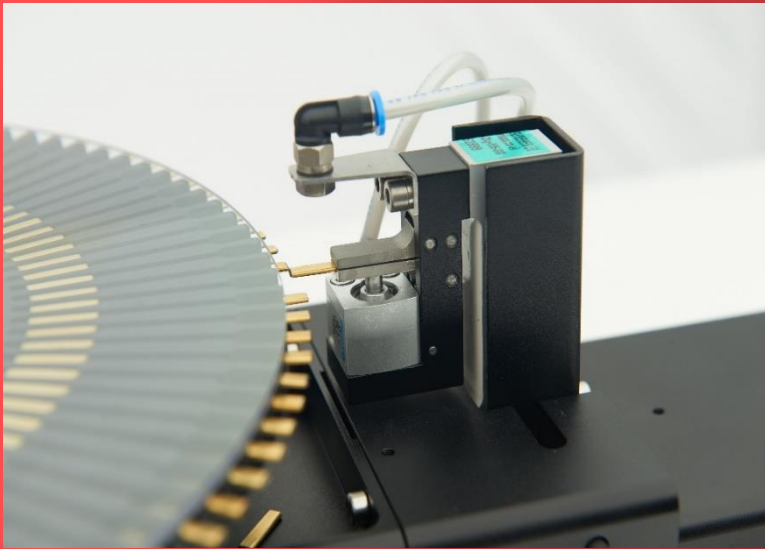
How To
Repair Damaged Hair

REPAIRS UP TO 1 YEAR OF DAMAGE IN 1 USE

Surface damage via Scanning Electron Microscopy (SEM)



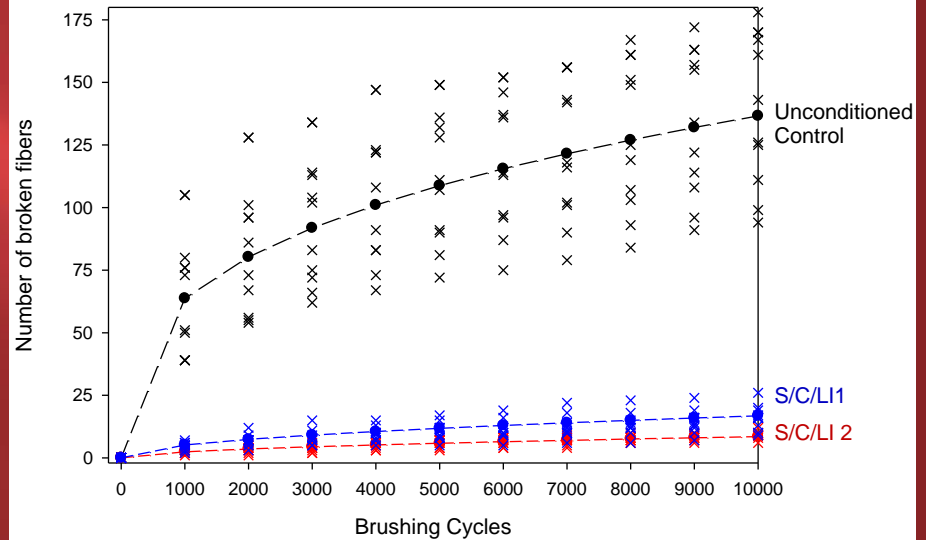
Decreasing tensile strength



Repeated grooming experiments



Weibull modeling of breakage data versus experimental data for repeated grooming testing on damaged hair



Extraordinary conclusions
require extraordinary evidence.

Summary/Conclusions

Hair possesses a bewildering complex bio-composite structure.

Hair comes in a wide variety of sizes shapes and colors.

The intrinsic properties of hair can be hugely altered by all the things we do to it.

Conventional daily products provide maintenance.

Thank you for your attention.

Questions ???

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