



# biochemistry

carbohydrates  
proteins  
amino acids  
lipids  
starch  
ketone  
isomers

● Sheet

○ Slides

Subject :	Fibrous proteins
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Number :	5

## Fibrous proteins

### COLLAGEN

1. What is the amino acid composition in collagen; what gives it its ability to do its function? What is the structure of collagen?  
Collagen is a fibrous **protein** and there is no such protein with a structure level lower than tertiary- since secondary structures are usually inside the protein and primary structures are elongated amino acids connected together-. Therefore, when we say protein we mean-at least- the tertiary (functional) structure even though the whole composition is in secondary structure. But what is the 'tertiary structure' of a protein? It is the 3D shape of the protein if it was a one polypeptide chain. On the other hand, if it had more than one polypeptide chain together forming the protein we call it **quaternary structure** like in the case of collagen since it is made up of more than one polypeptide chain. Every tropocollagen (collagen basic unit) is linked with other tropocollagen molecules via cross links(covalent bonds).
2. What is the composition of collagen that makes it behave as a fibrous protein and look like one? That each of its tropocollagen molecule is composed of **alpha chains** that are closely linked/packed together(intertwined). They are rich in glycine that makes them packed to look like fibers eventually. Moreover, the feature that makes it a strong protein is the presence of many tropocollagen monomers connected together through covalent interactions called cross-links making the protein very strong. It is packed together since glycine is small it can pack the chains together and proline gives each chain the better helical form.(proline creates the kinks thus stabilizing the helical structure)
3. What makes it able to do cross-links and hydrogen bonding? The presence of hydroxyproline(H-bonds between chains) and

lysine(oxidized form)→(cross-links between chains and between different tropocollagen molecules). Hydroxylysine serves as an attachment site for sugars; carbohydrates, this is why when we want to define collagen: we say it is a **glycoprotein** because it is always linked to carbohydrates.(it is a glycosylated protein)

4. Scurvy(Vitamin c deficiency disease) because the enzyme which hydroxylates proline is vitamin c dependent. So if no Vit c→no hydroxyproline→no H-bonds→less strength to collagen→fragile vessels and teeth become loose in their sockets.

## ELASTIN

1. All of the elastin components are collected together randomly( like a fur ball) and attached together through hydrogen bonds to stabilize it( in addition to covalent bonds(cross links) to prevent separation when stretched) and all of its interior is **hydrophobic** linked through hydrophobic interactions together and hides from water as much as possible and this is the best stable condition for hydrophobic content.
2. Elastin is a big protein made up of monomers(tropoelastin) that are linked together in a way to stay linked together so once you stretch it, it won't become further apart from each other and won't break eventually, and that is done through covalent interactions called cross-links which allow elastin to go back to its original shape. In elastin the oxidation takes place between lysine residues(to make lysine make cross-links). Note that in collagen there are two enzymes concerning lysine: one responsible for hydroxylation (lysyl hydroxylase) produces hydroxylysine and one for oxidation (lysyl oxidase)→produces allysine.
3. When we talked about collagen and its properties we mentioned that it contains hydroxylysine that serves as an attachment site for sugars because when sugars bind to proteins it is not a

random process; they bind at certain oxygens; one of them the oxygen for serine,...) Or sometimes hydroxylysine, so the presence of hydroxylysine in collagen was to serve mainly as an attachment site for carbohydrates. However if I want to define elastin I say it is **not a glycosylated protein** like collagen therefore elastic tissue **doesn't contain hydroxylysine** nor lysylhydroxylase. Basically elastin unit is monomer with no formal shape its name is tropoelastin connected with other tropoelastin molecules through covalent bonds between lysine residues(oxidized). The amount of cross linking in collagen, elastin and other fibrous proteins increases with age.

\*Where is this applicable? In meat; anyone that goes to buy meat from the butcher would prefer to buy a younger aged sheep or veal why? Because it would be tender since its young which means less amount of cross-linkages, however if you bought an older one and tried to cook it at home, it will be cooked but way slower than the usual because of the larger amount of cross-linkages.

4. How does the process of crosslinking occur between the elastin protein? Lysine residues in one tropoelastin gather around each other and be close to each other, 3 lysine residues already oxidized by lysyloxidase (Allysine residues that don't contain nitrogen) with a 4<sup>th</sup> residue(unmodified lysine-not oxidized form -so it contains nitrogen), when collect them together, lysyloxidase will remove the nitrogen and bonds them together ... when they unite together they form a ring.

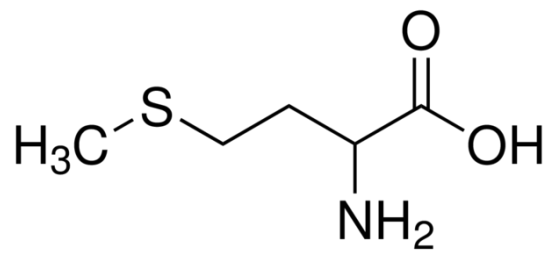
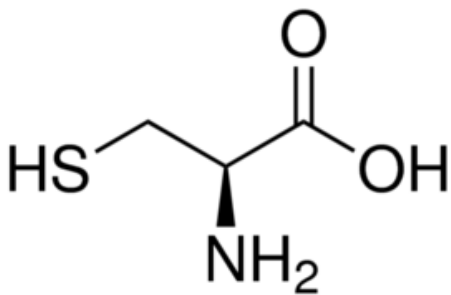
\*What makes elastin strong? **Desmosines**. Desmosines are made up of 4 lysine residues that form a ring, 3 of which are oxidized to Allysine and 1 which isn't oxidized. The 3 oxidized Allysines unite with the 4th lysine to create a ring known as a desmosine ring, which makes elastic tissue strong.

5. Why does elastic go back to the way it is after we stretch it (flexibility)? Hydrophobic interactions make it as much compact as they can to each other, one of the properties of hydrophobic interactions is that they are weak so once we apply a force we break it, yet the protein is not broke; since there are covalent cross linkages that can't be broken and later they can't stay in the aqueous manner, so the h.phobic regions go back to each other and pack together... if we look at its components it contains a lot of hydrophobic amino acids.

### **KERATIN**

1. 3<sup>rd</sup> example of **fibrous** proteins.
2. Its main component or monomer is **alpha helix**. Two  $\alpha$ -helices wrap around each other to make what's known as a **coiled coil**, 2 of them get together to make up protofilament, then **protofibril**, then **microfibril**, then **macrofibril**, **fibrils** and **fibers**.
3. Where is keratin found? In hair, nail, skin and skin appendages; which all have 'hardness' as a common feature.
4. So what is the amino acid composition that gives keratin its hardness for the protein? **Cysteine**; which is the only amino acid that can form covalent bonds (disulfide bonds)

\*How does methionine differ from cysteine? In the location of sulfur; Cysteine is a polar amino acid because the sulfur is terminal (SH) and we call it **thiol** group. In contrast, in methionine there is no thiol group because the sulfur is not terminal and is bonded from both sides (**thioether**). it is not reactive and we called it non-polar. That is why cysteine can form disulfide bridges while methionine can't.



5. Depending on the percentage of cysteine abundant in keratin we divide it into hard and soft.(More cysteine→more disulfide bonds which are covalent(strong)→more hardness.(this is why keratin of the hair is less hard than keratin of nails)

6. Keratin has two types: alpha and beta

	Alpha keratin	Beta keratin
Location	In human	Reptiles, birds(makes up their feather)

7. Why is it that when we place hot water or cold water or use a certain commercial product or even use a hair-blower our hair becomes silky? So the role of water is to hydrogen bond with the amino acid contents that make up the alpha helices then it starts to **separate the hydrogen bonds that are already existing** in the keratin and this is temporarily because after a while hydrogen bonds will start forming again.

\*The difference between hot and cold water lies within the temperature this is why the hot water is more effective in breaking down the hydrogen bonds than cold water. The hair dryer is also effective

whether it was hot or cold air because the force applied by it alone is enough to break the hydrogen bonds.

8. How do we make our hair **permanently** straight? In order to change the texture of the hair we need to **break the disulfide bridges**, then apply reducing agents such as ammonium thioglycolate, when the reduction happens the hair will become straight, and then you will need to **re-oxidize** the thiol groups to reform the disulphide bridges while the hair is straight. The more disulfide bridges you have the straighter the hair.