The formation of disulfide bonds has a direct application in producing curls in hair by the permanent wave process. Hair keratin consists of many protein alpha-helices. Three alpha-helices are interwoven into a left-handed coil called a protofibril. Eleven protofibrils are bonded and coiled together to make a microfibril. Hundreds of these microfibrils are cemented into an irregular bundle called a macrofibril. These in turn are mixed with dead and living cells to make a complete strand of hair.

**Introduction**

Although it may seem incredible, in order for hair to grow 6 inches in one year, 9-1/2 turns of a -helix must be produced every second. The alpha-helices are extensively cross-linked with disulfide bonds from cysteine. These bonds enable keratin to have a somewhat elastic nature. If the alpha-helices stretch unevenly past each other, the disulfide cross-links return them to the original position when the tension is released.

**Disulfide Bonds**

Disulfide bonds are formed by oxidation of the sulphydryl groups on cysteine. Different protein chains or loops within a single chain are held together by the strong covalent disulfide bonds. The alpha-helices in the hair strands are bonded by disulfide links. In the permanent wave process, a basic reducing substance (usually ammonium thioglycolate) is first added to reduce and rupture some of the disulfide cross-links.
Waves

When the hair gets wet, water molecules intrude into the keratin strands. The sheer numbers of water molecules are able to disrupt some of the hydrogen bonds which also help to keep the alpha-helices aligned. The helices are able to slip past each other and will retain a new shape in the hair drying process as new hydrogen bonds are formed. The hair strands are able for a short time to maintain the new curl in the hair.

For a permanent wave, we will continue the discussion from the use of the reducing agent. The hair is put on rollers or curlers. Since the alpha-helices are no longer tightly cross-linked to each other, the alpha-helices can shift positions in relation to each other. An oxidizing agent, usually a dilute solution of hydrogen peroxide, (also called the neutralizer) is added to reform the disulfide bonds in their new positions. The permanent will hold these new disulfide bond positions until the hair grows out, since new hair growth is of course not treated.
Contributors

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![Permanent Wave Diagram](image)