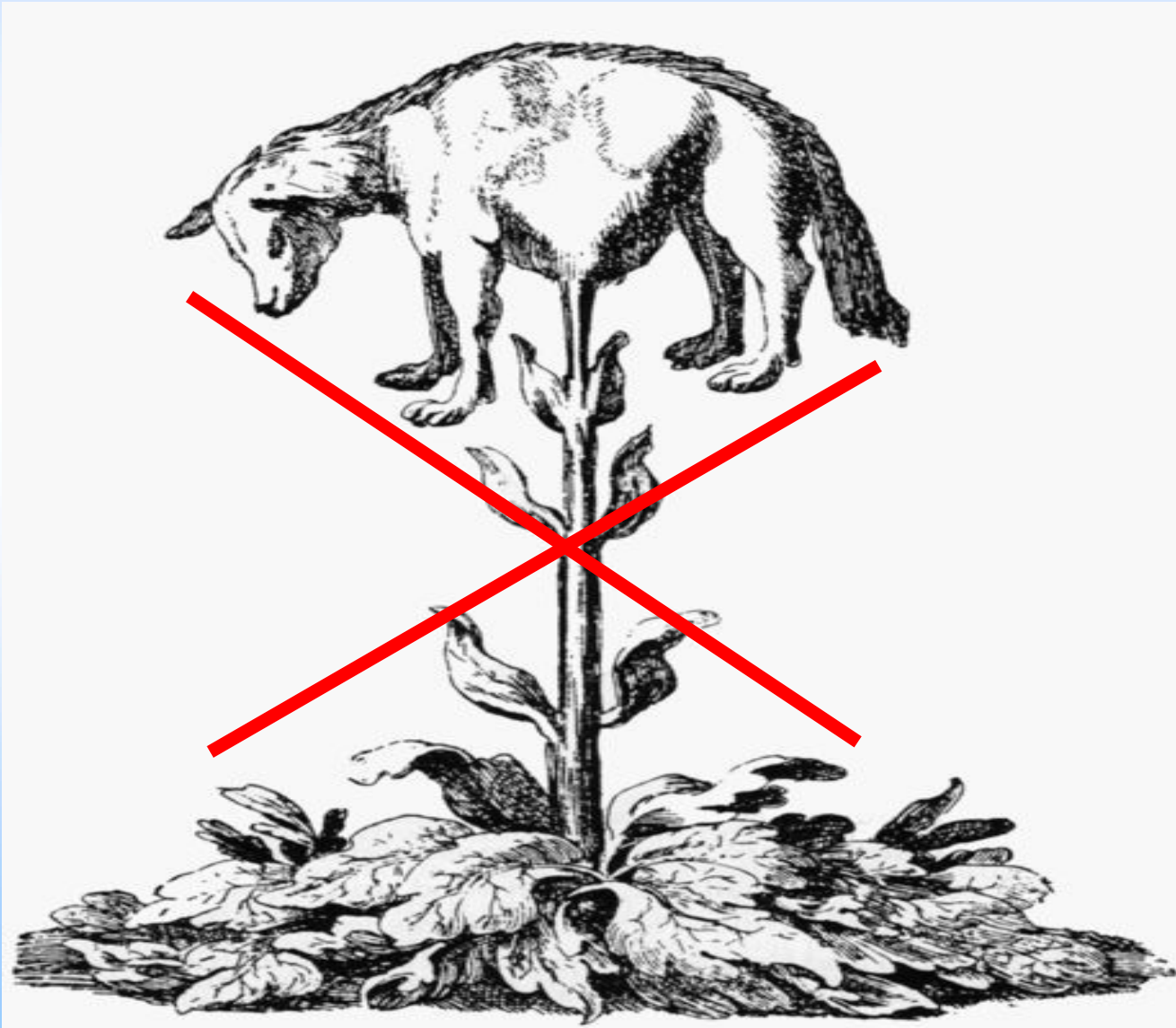




Textile chemistry

Textile fibres



Jakub Wiener



COARSE WOOL

FINE WOOL

ALPACA

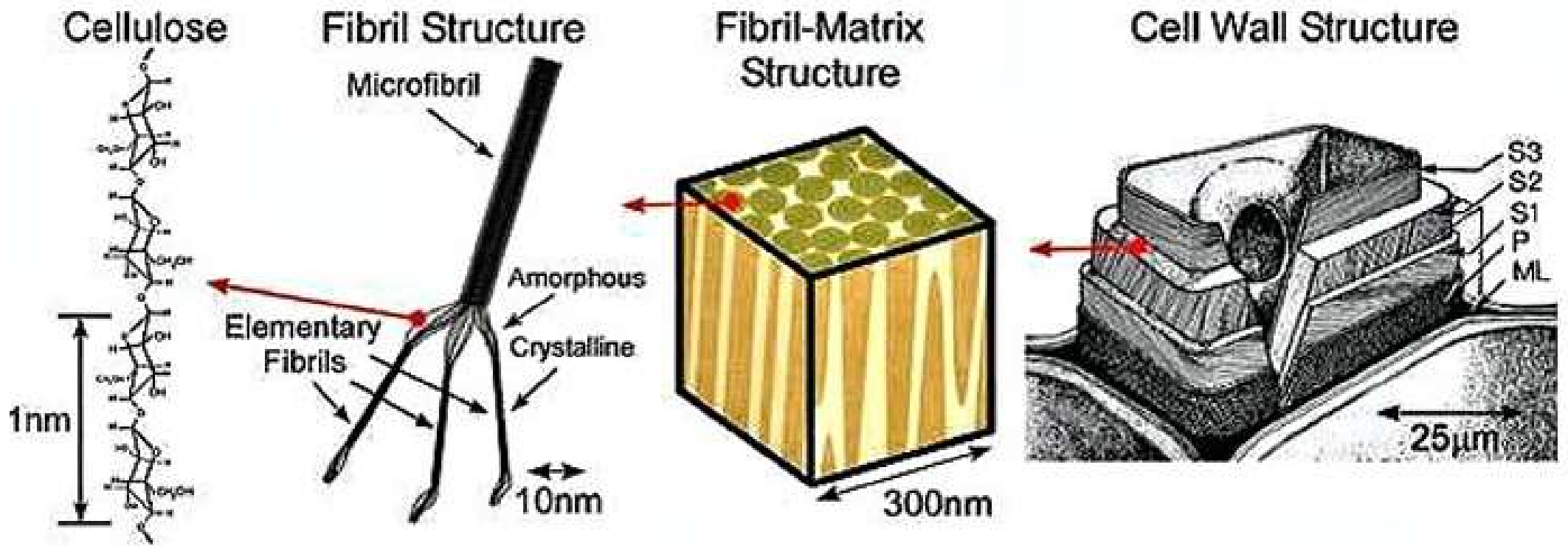
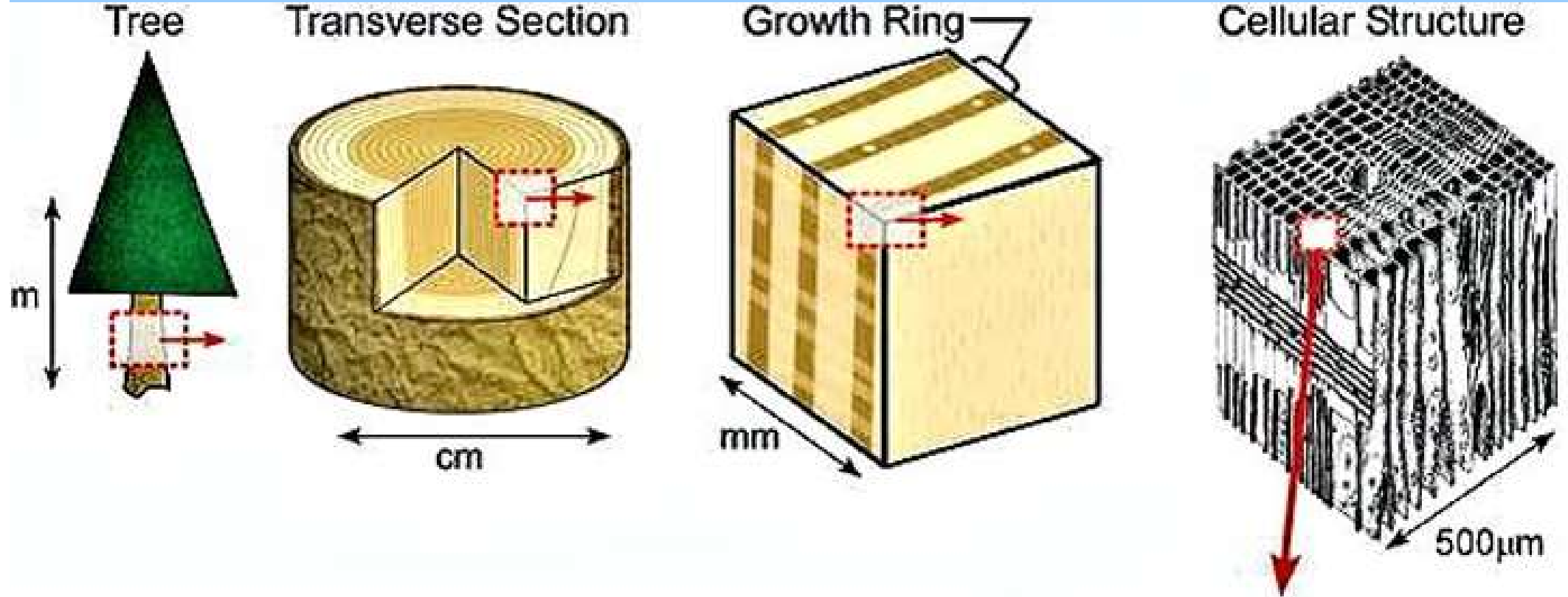
CASHMERE

SILK

LINEN

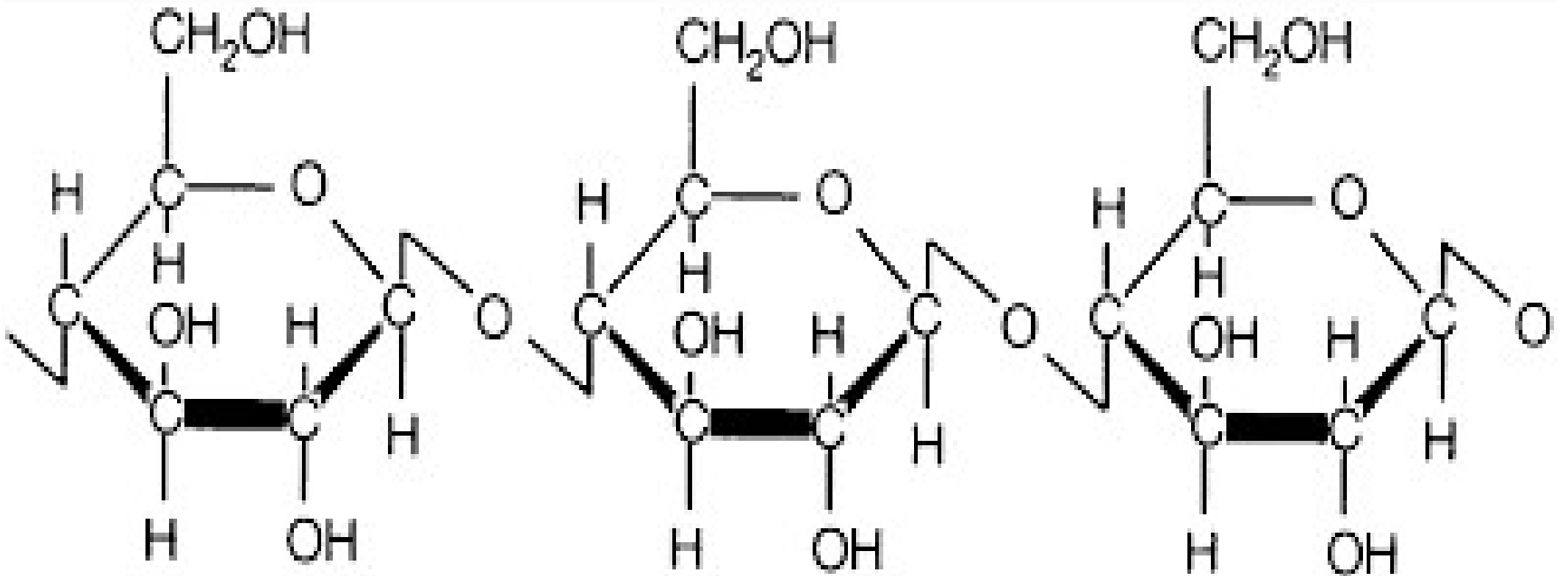
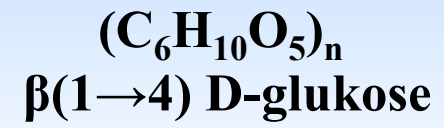
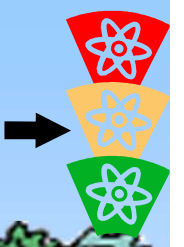
COTTON

POLYESTER



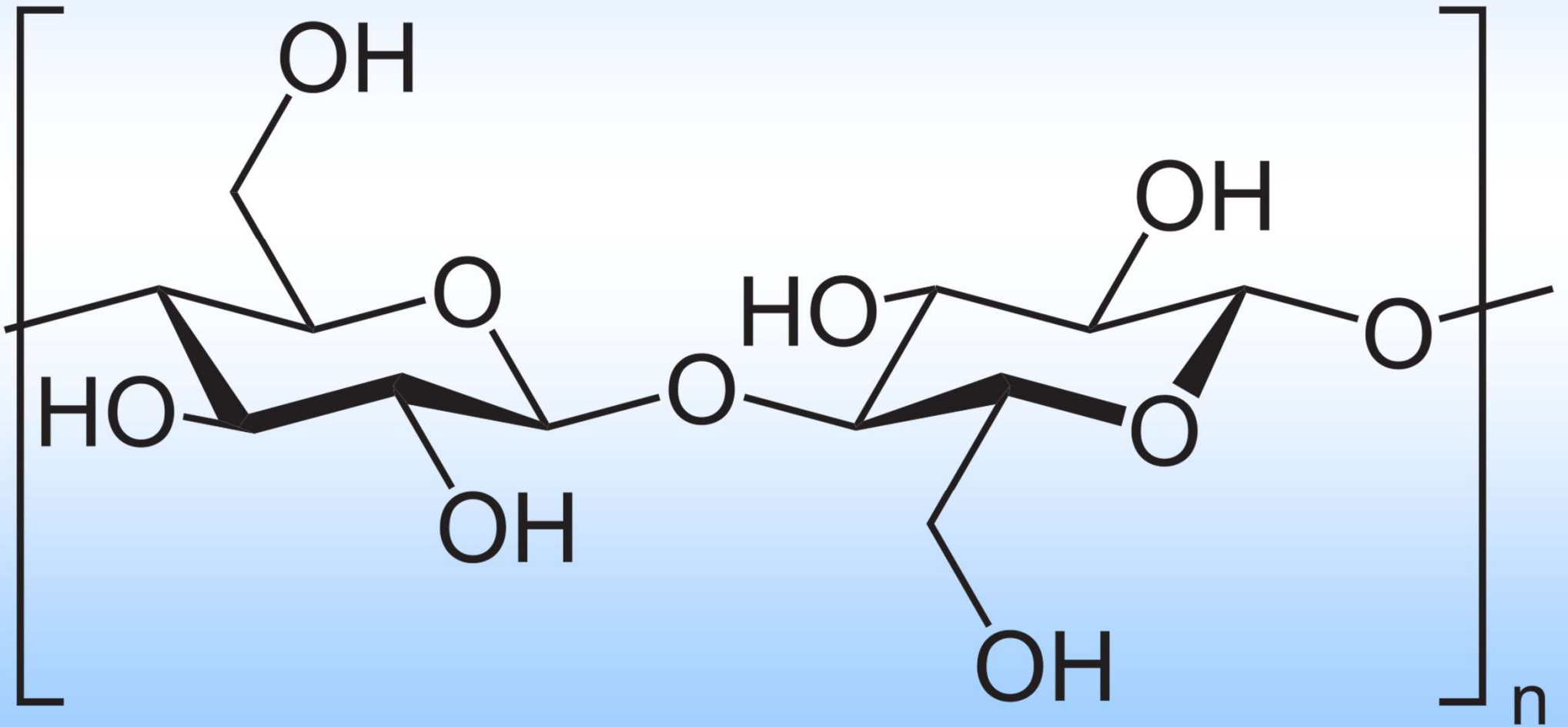
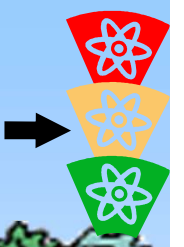


CELLULOSE

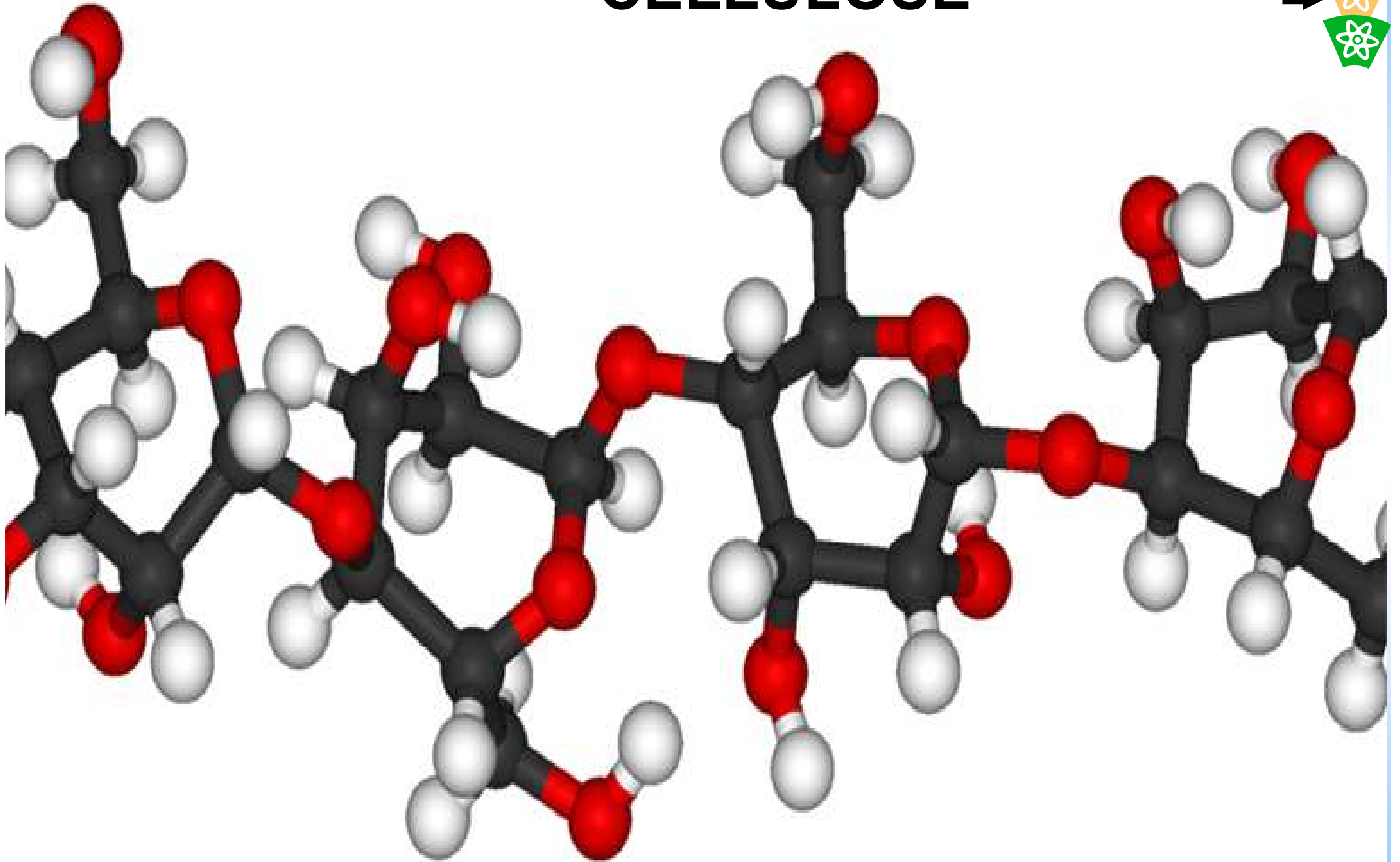
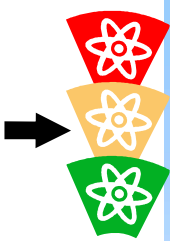




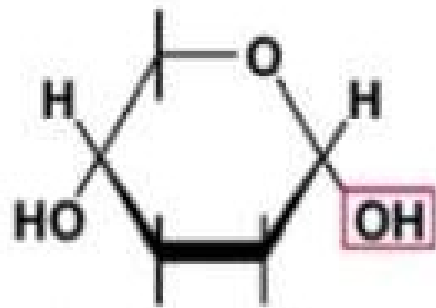
CELLULOSE



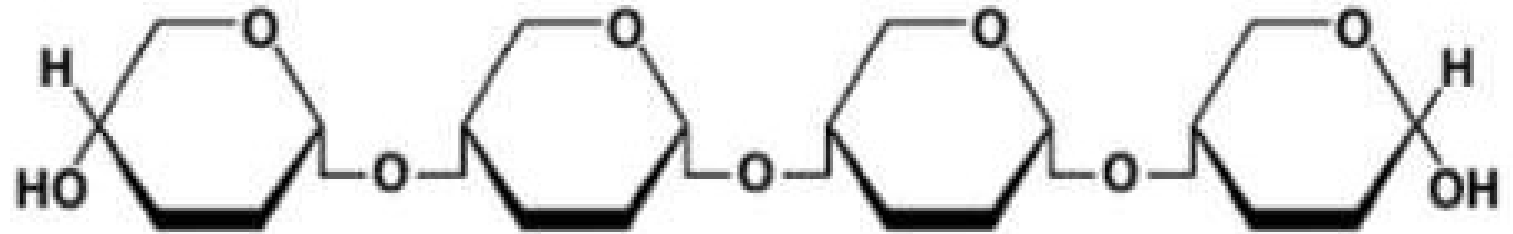
CELLULOSE



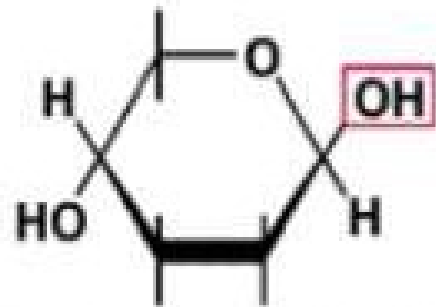
Alpha-glucose and Beta-glucose, Plus Primary Structures of Amylose and Cellulose



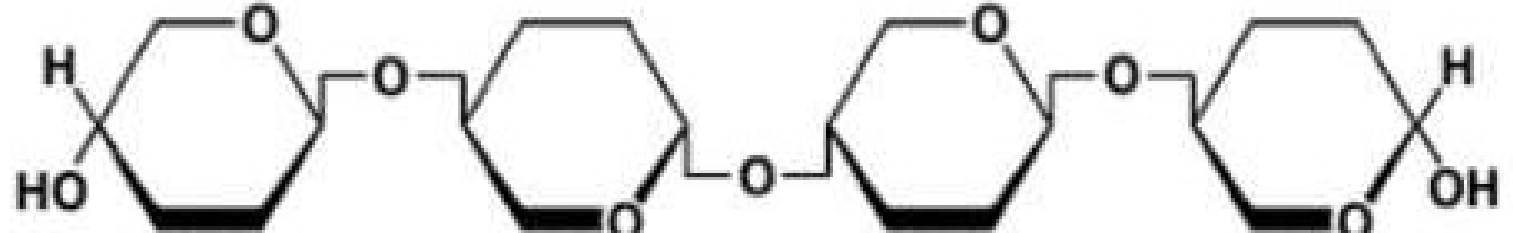
Alpha-glucose



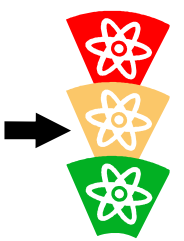
Amylose



Beta-glucose



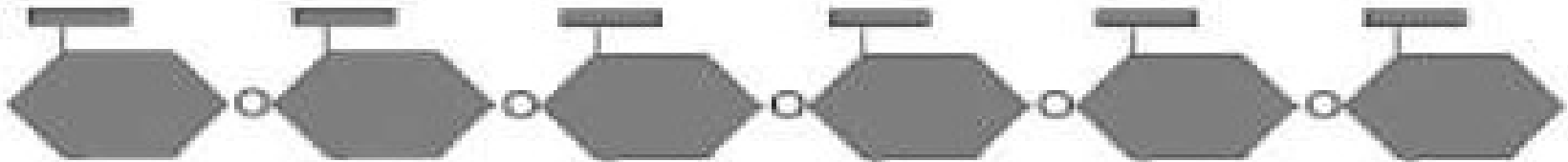
Cellulose



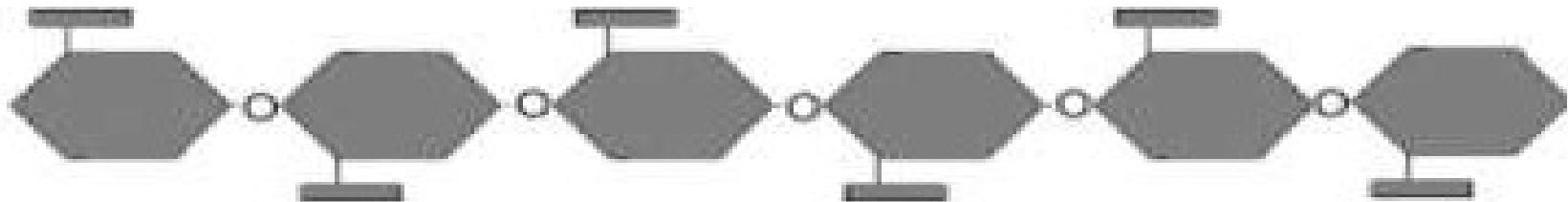
Polysaccharides...



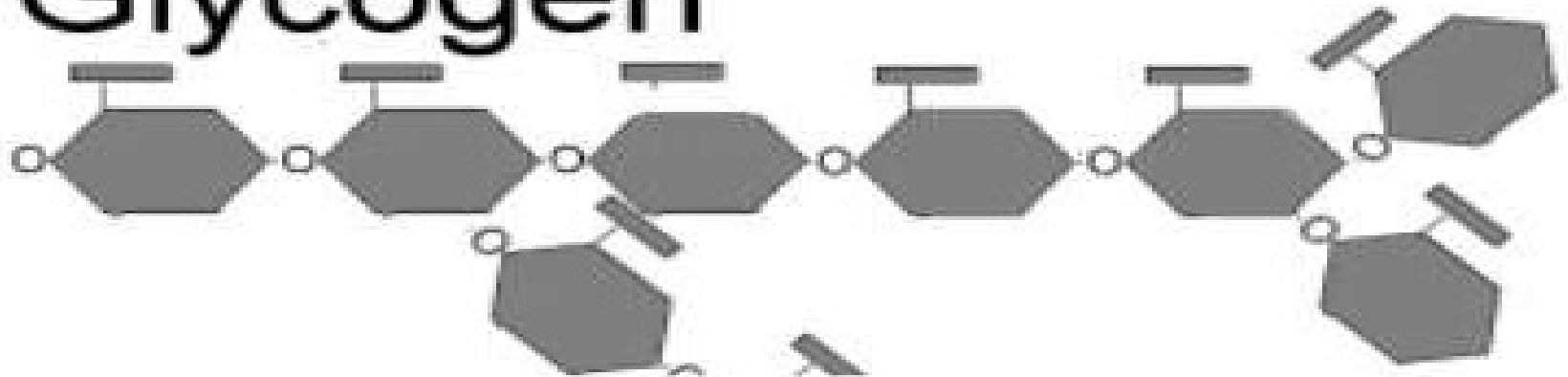
Starch



Cellulose

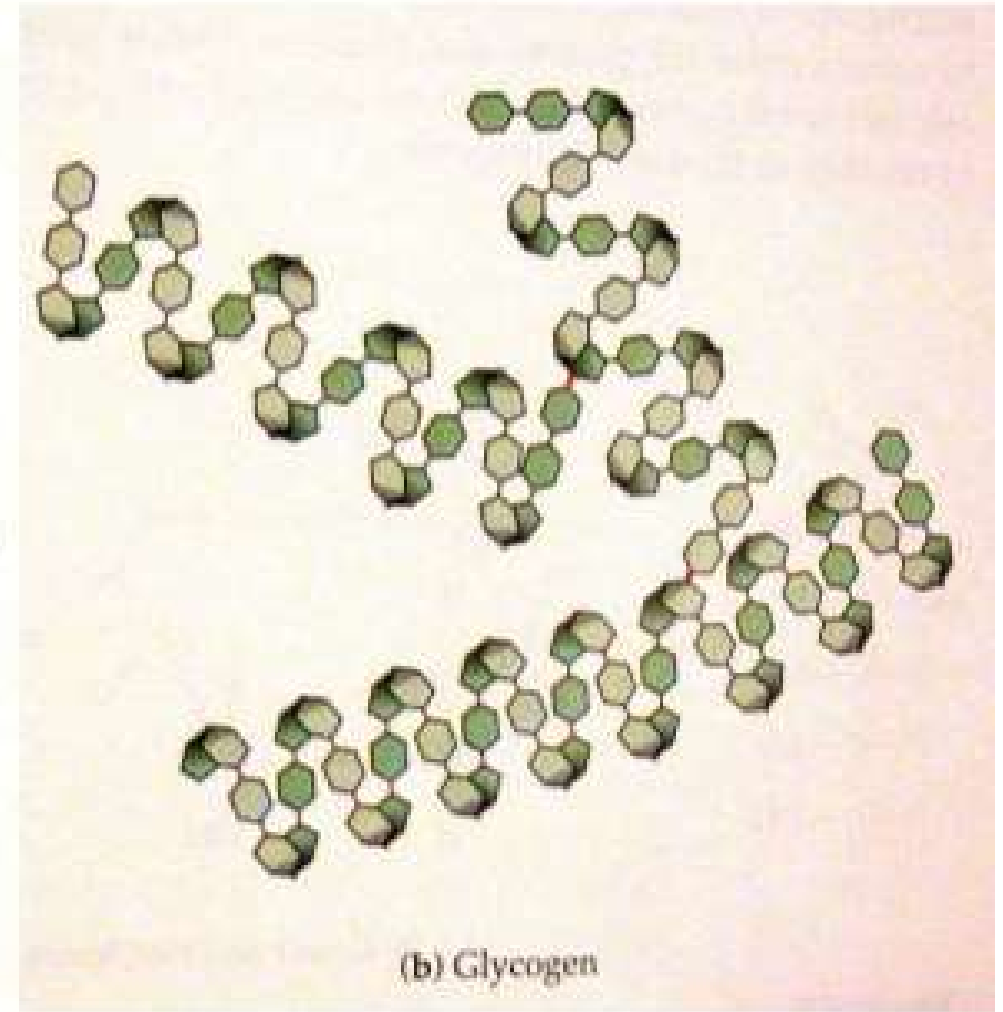
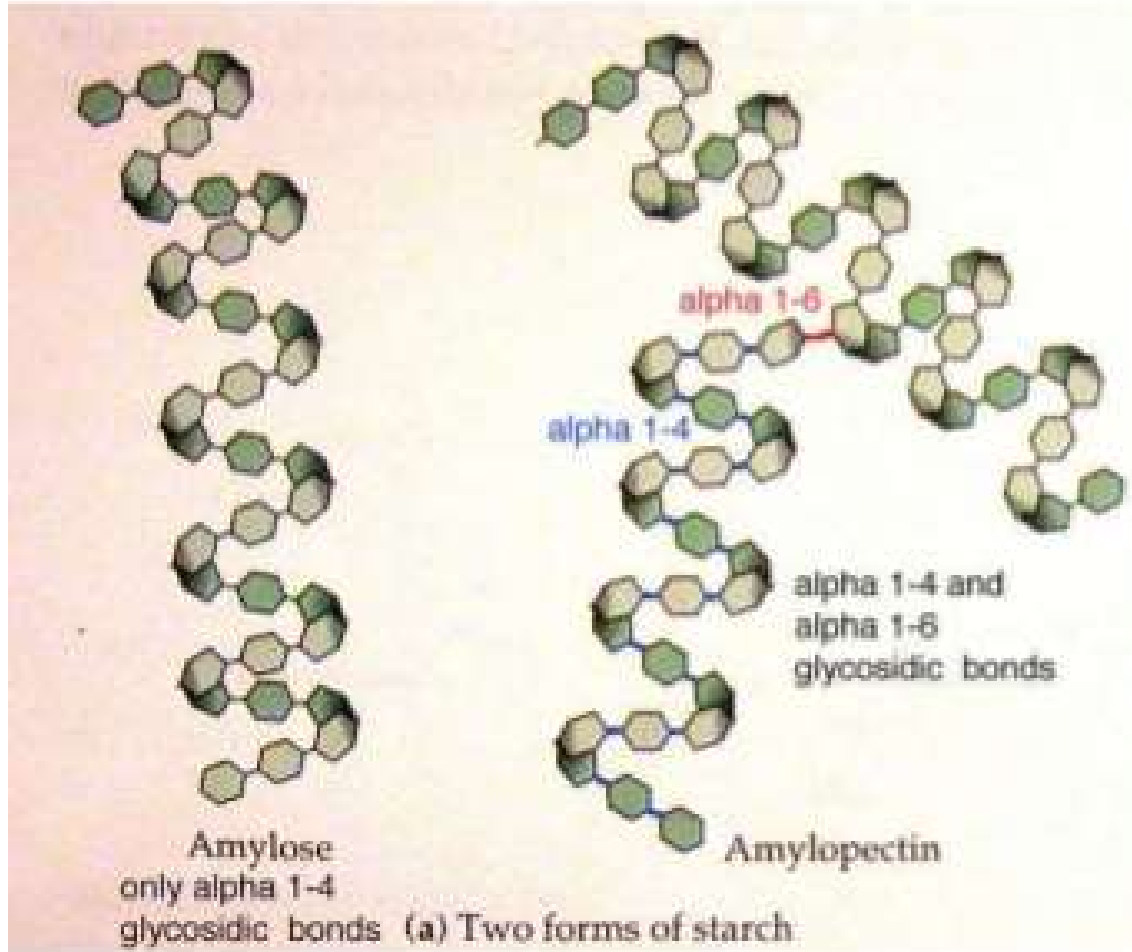
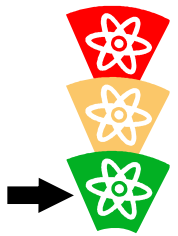


Glycogen



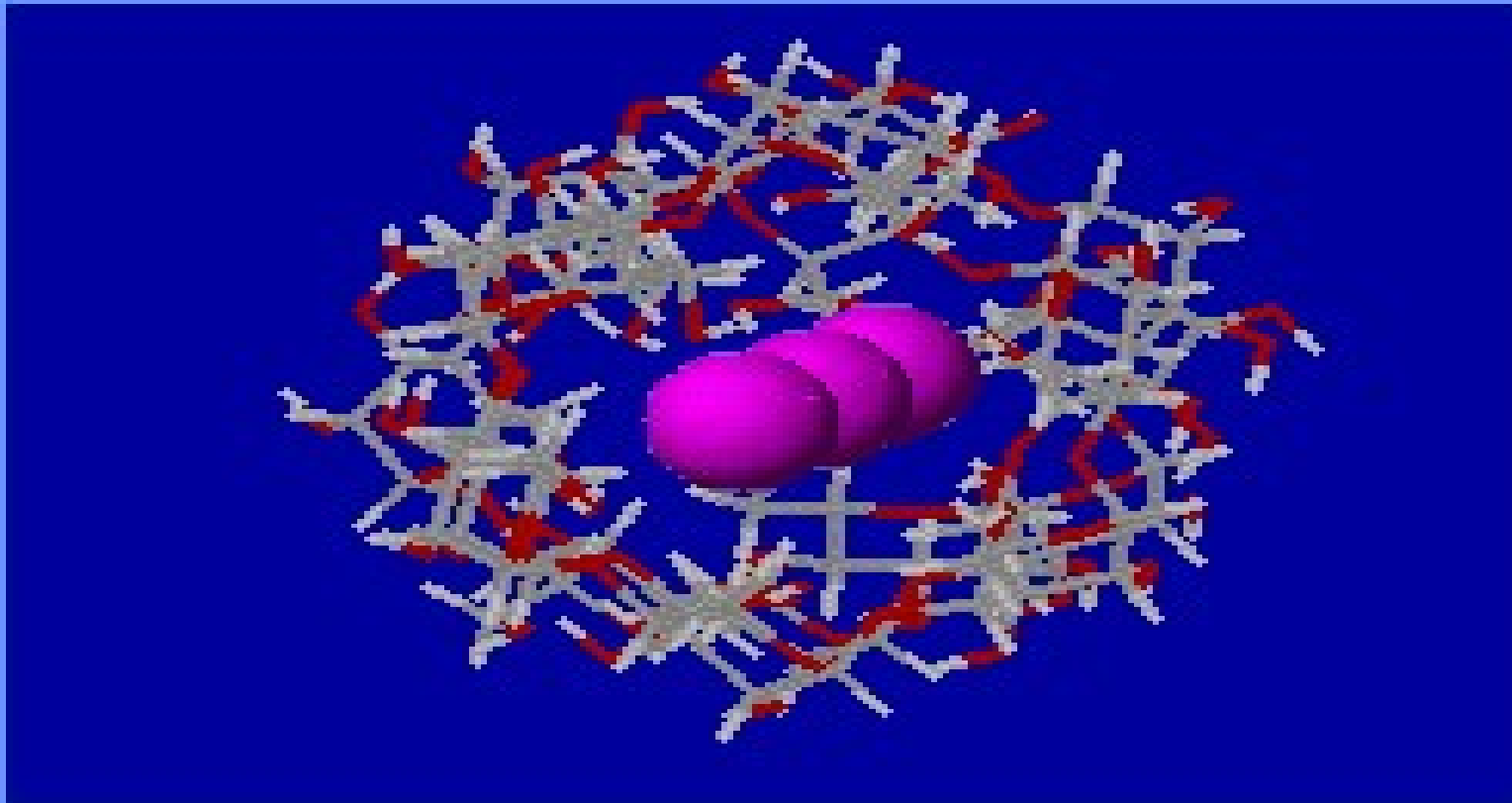
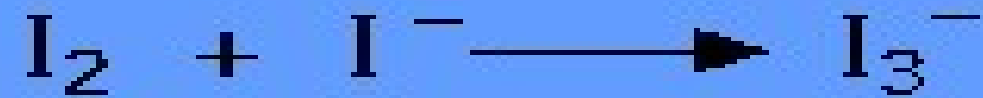
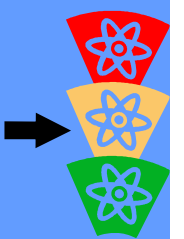


Starch Vs Glycogen...



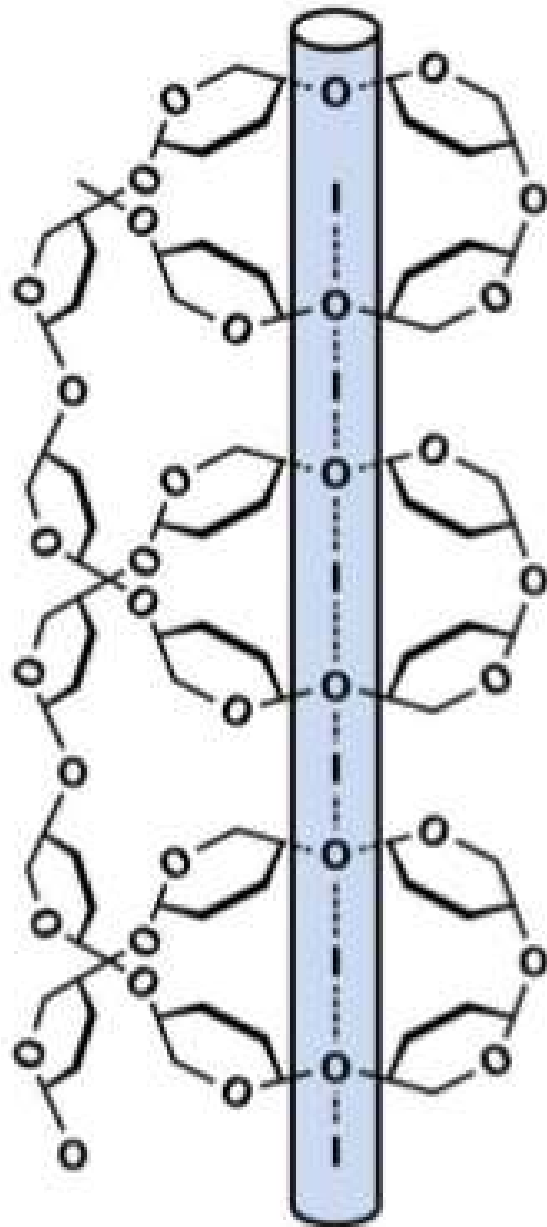
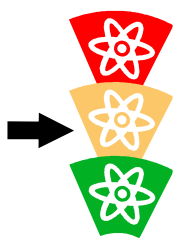
$\alpha(1,4)$; $\alpha(1,6)$ glucose

Starch - Iodine Complex



Iodine slides into starch coil
to give a blue-black color

Starch-Iodine Complex



- Starch is the indicator of choice for those procedures involving iodine because it forms an intense blue complex with iodine. Starch is not a redox indicator; it responds specifically to the presence of I_2 , not to a change in redox potential.
- The active fraction of starch is amylose, a polymer of the sugar α -D-glucose.
- In the presence of starch, iodine forms I_2 chains inside the amylose helix and the color turns dark blue

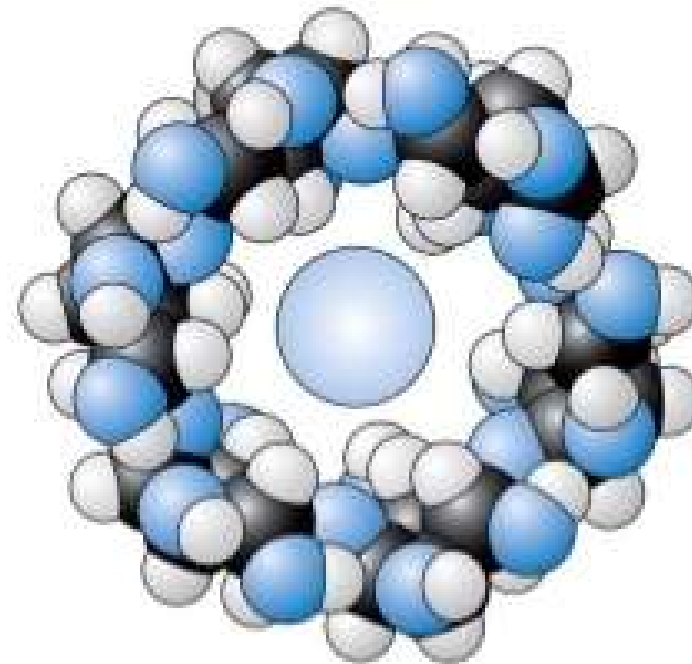
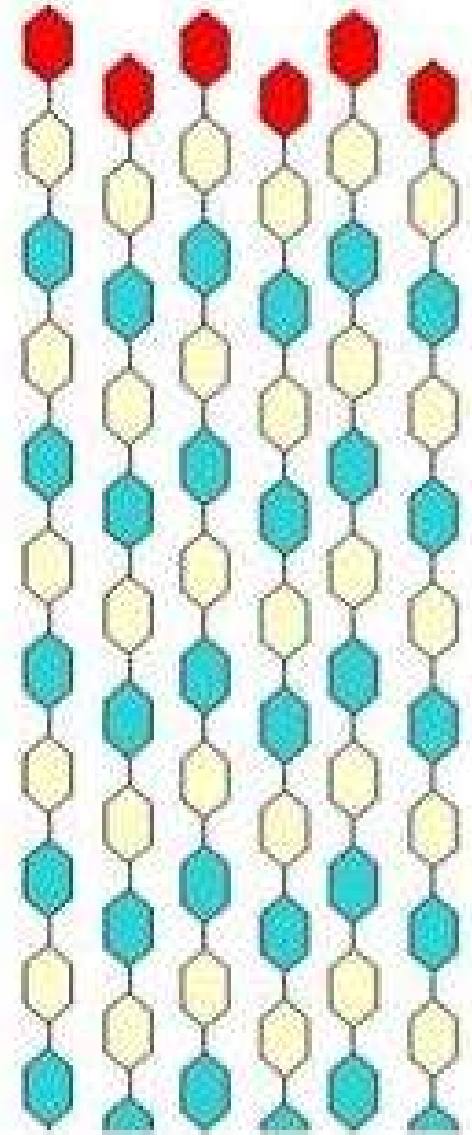
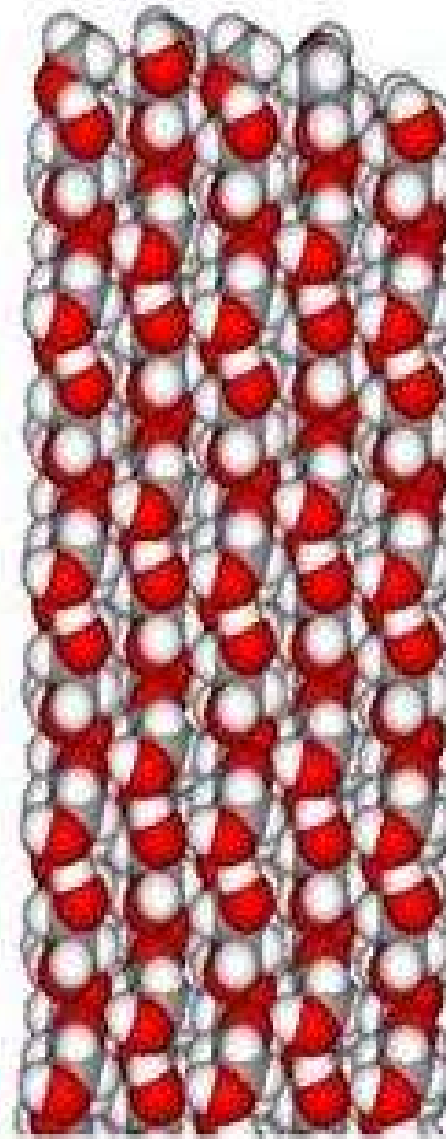
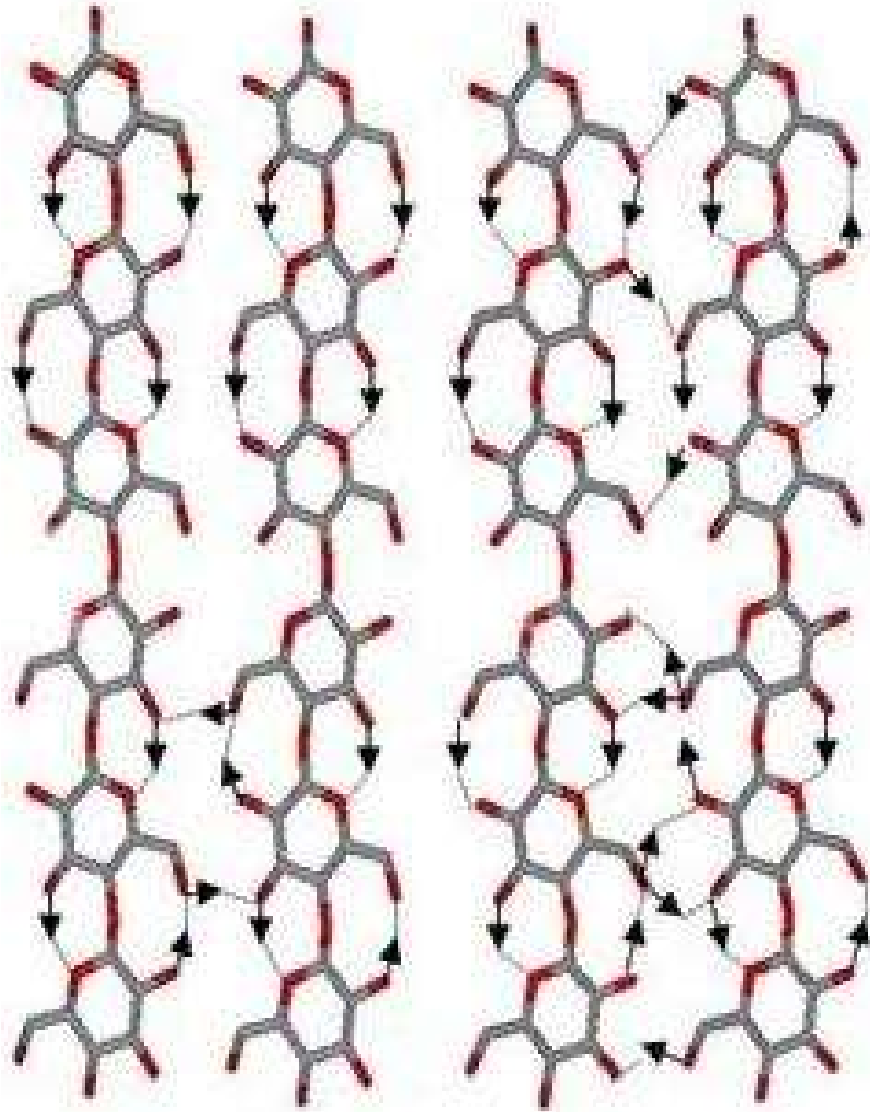
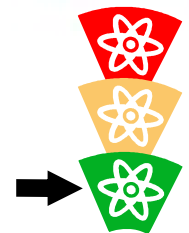


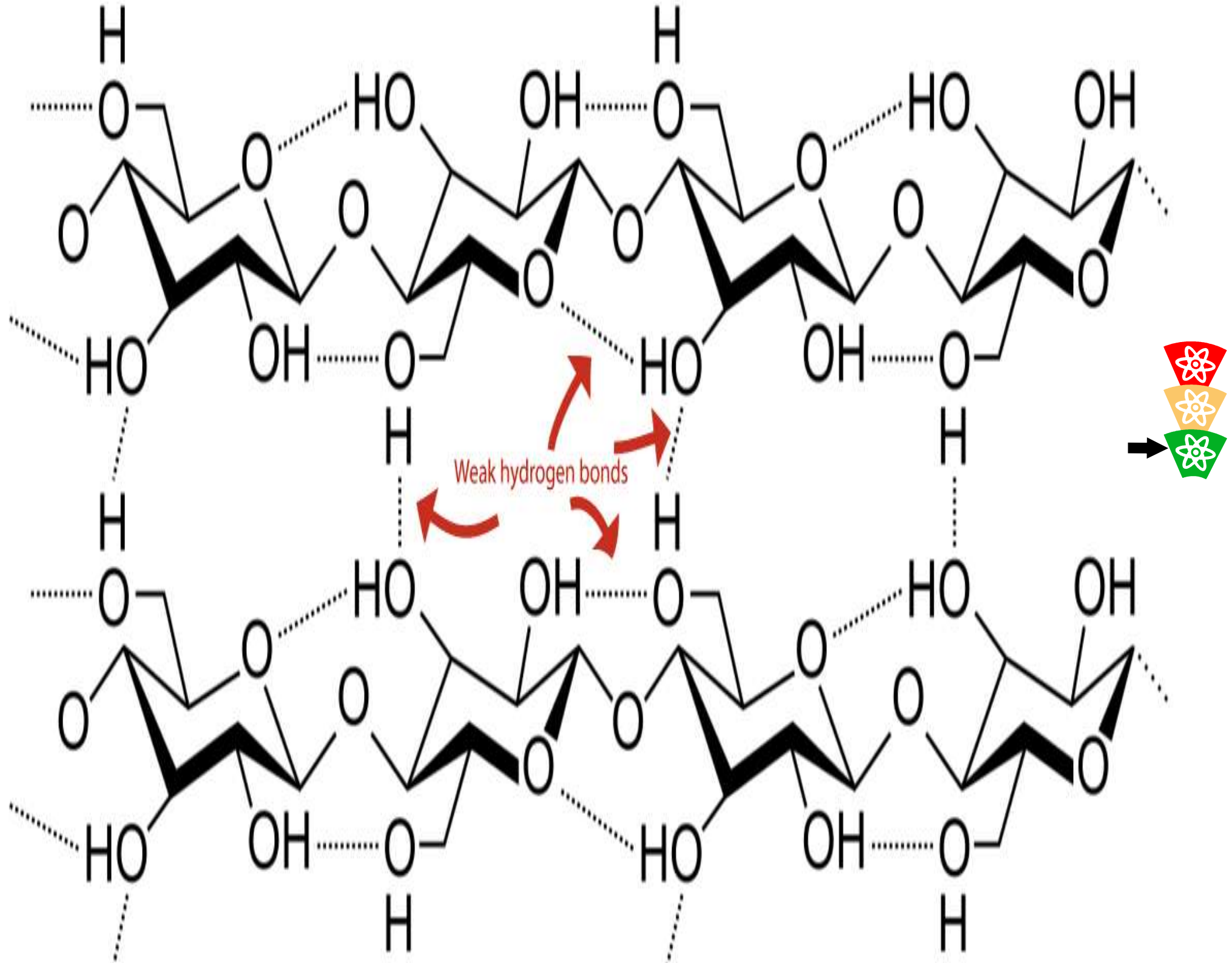
Figure 16-6a
Quantitative Chemical Analysis, Seventh Edition
© 2007 W. H. Freeman and Company

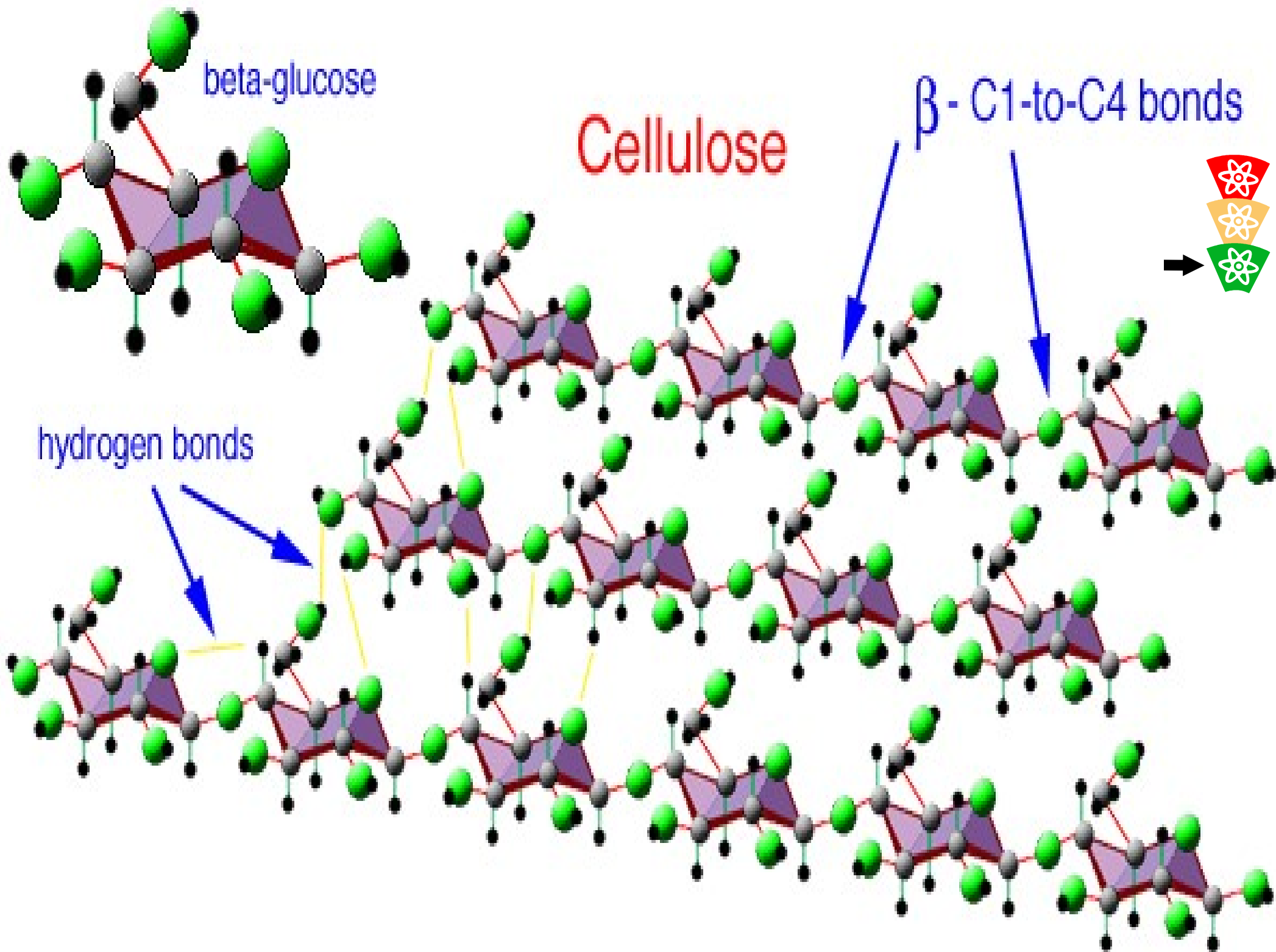
Figure 16-6b
Quantitative Chemical Analysis, Seventh Edition
© 2007 W. H. Freeman and Company



Cellulose ... fibers !

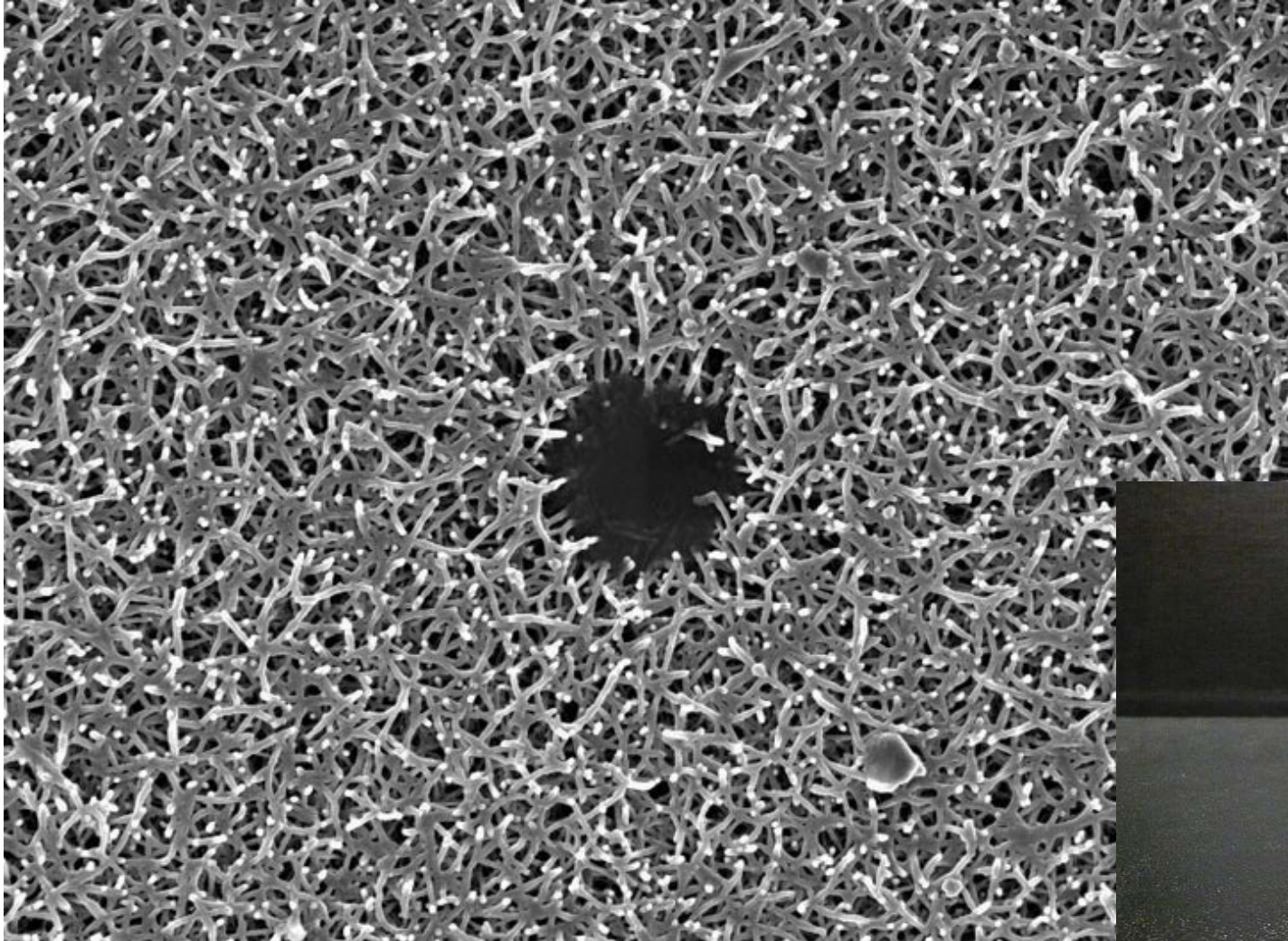
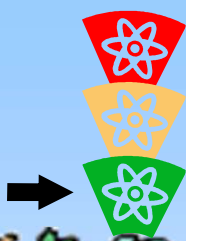








Nano cellulose





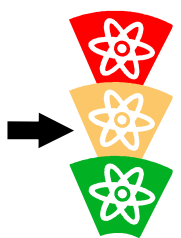
CELLULOSE



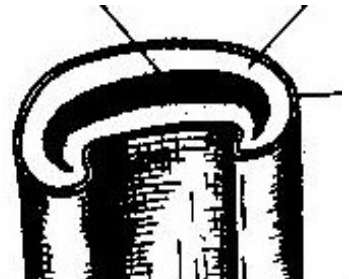
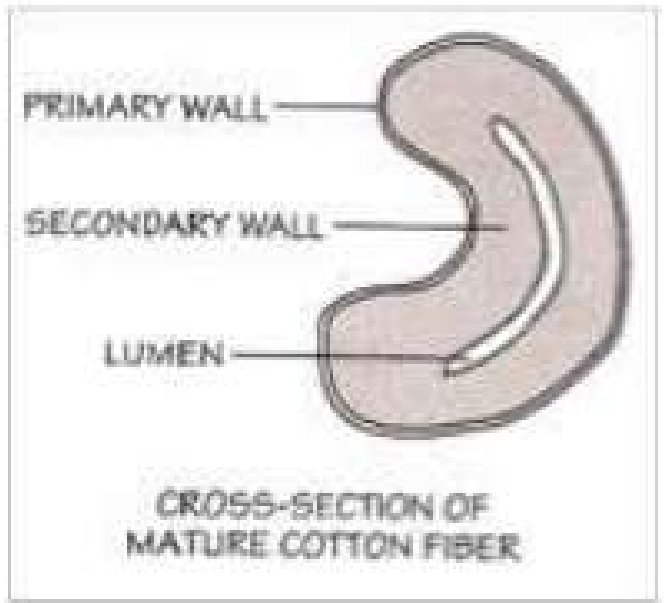
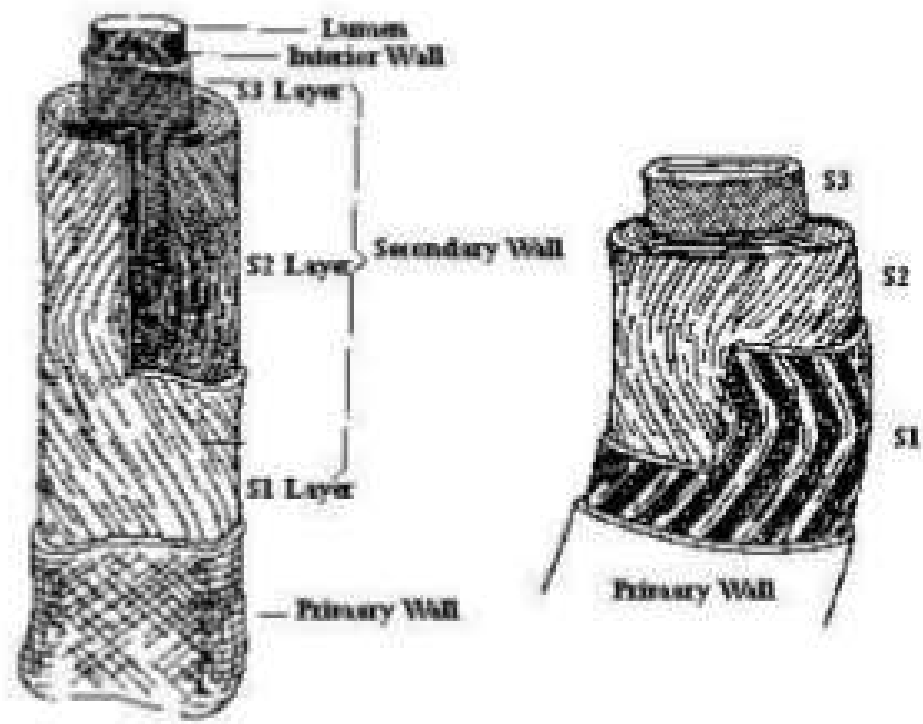
CELLULOSE



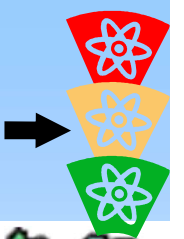
The micro-structure of cotton fiber-



- Its cross-section is oval, compared with the normal hexagonal plant cell. However, like all plant cells, cotton has a distinct cuticle, well developed primary and secondary walls, and a lumen.



Cotton

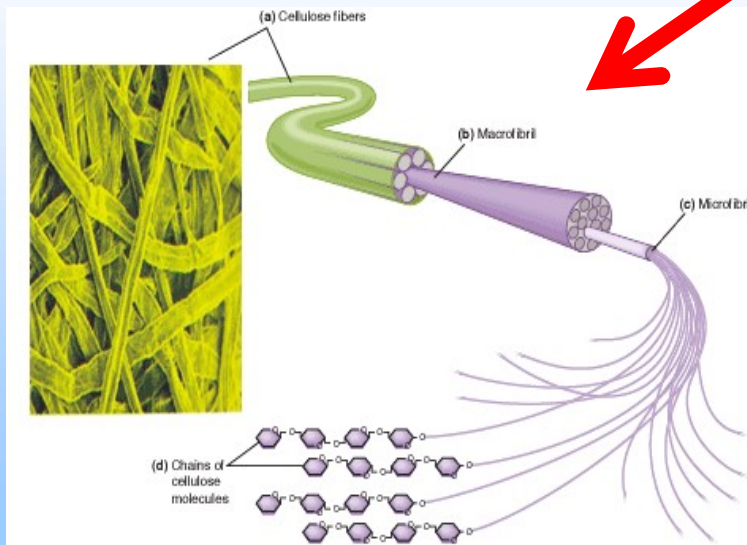
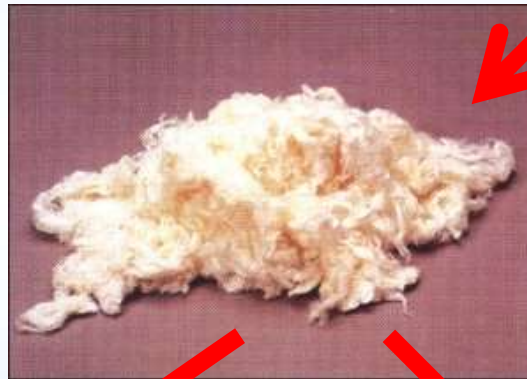
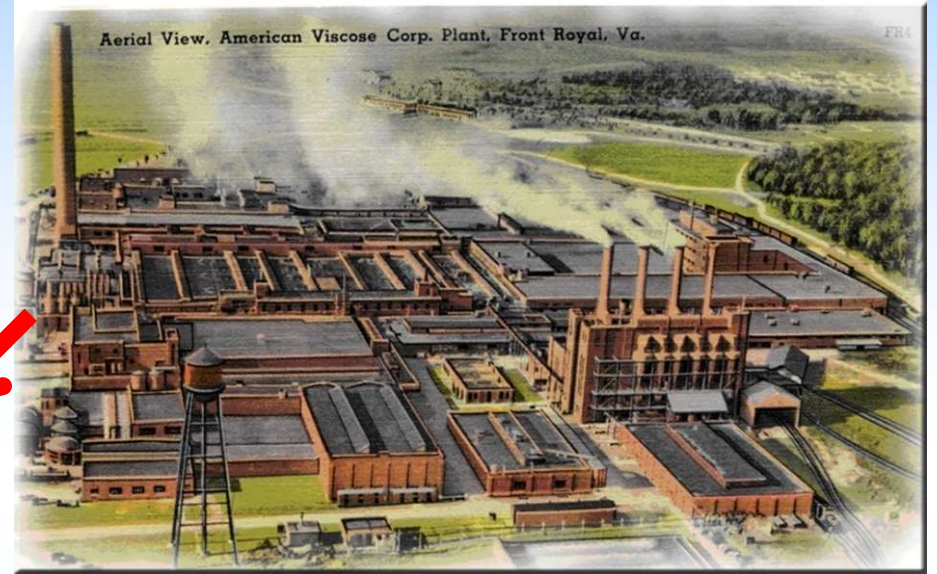
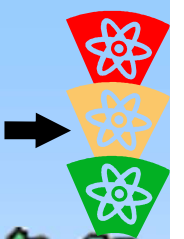


Composition of cotton

- **Natural impurities**

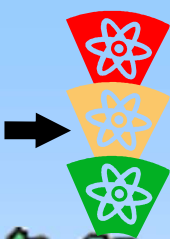
- | Constituent | % |
|------------------|-----|
| Cellulose | 88 |
| Oils and Waxes | 0.5 |
| Pectins | 0.7 |
| Proteins | 1.1 |
| Colouring matter | 0.5 |
| Mineral Matter | 1.0 |
| Moisture | 8.0 |

viscose





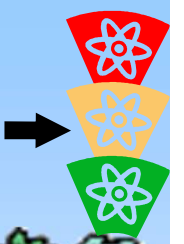
viscose



Viscose rayon is a fiber of regenerated cellulose; it is structurally similar to cotton but may be produced from a variety of plants such as soy, bamboo, and sugar cane. Cellulose is a linear polymer of β -D-glucose units with the empirical formula $(C_6H_{10}O_5)_n$

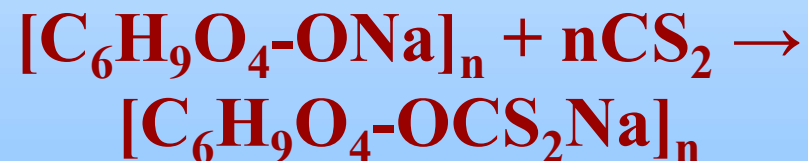


viscose



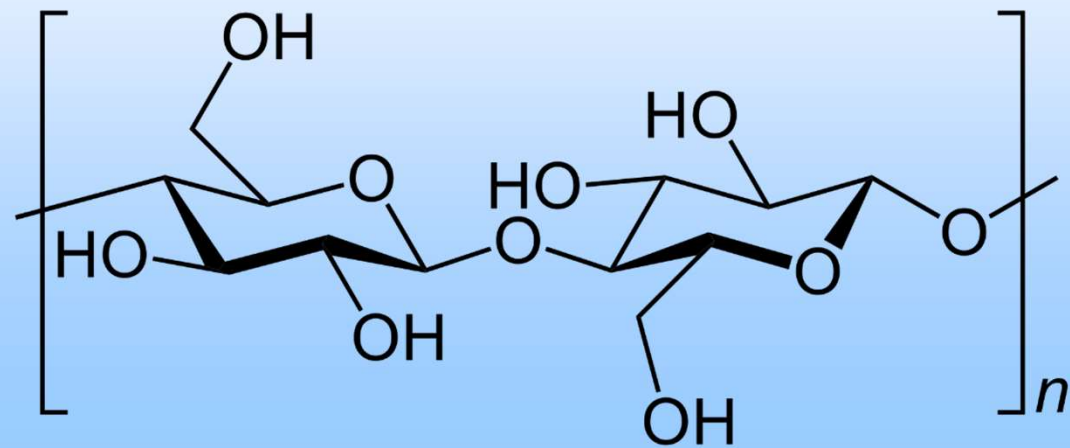
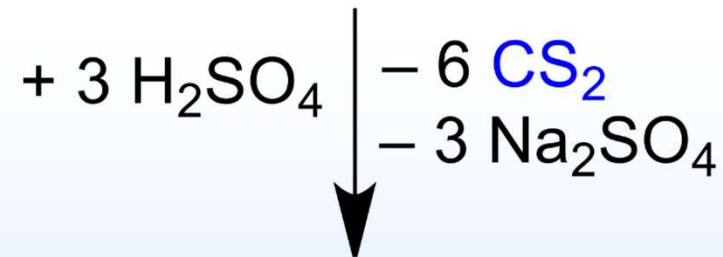
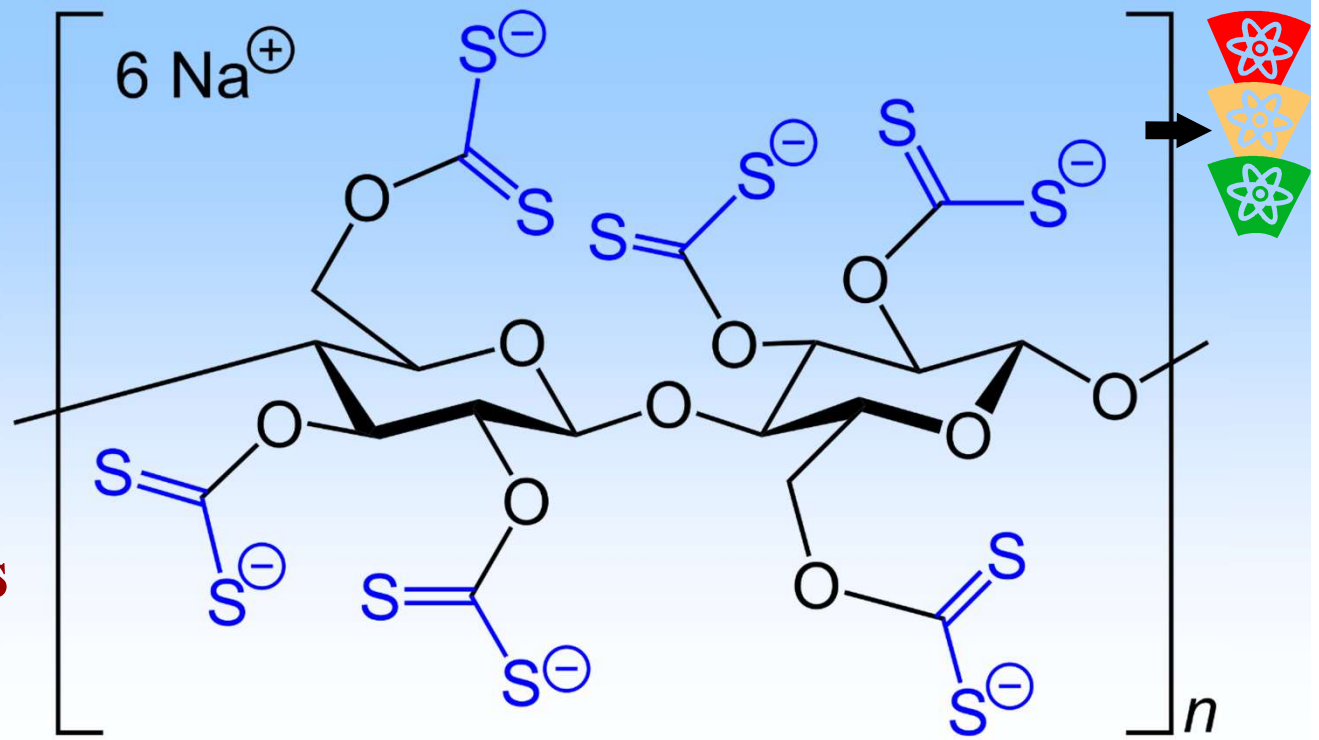
To prepare viscose, dissolving pulp is treated with aqueous sodium hydroxide (typically 16-19% w/w) to form "alkali cellulose," which has the approximate formula $[\text{C}_6\text{H}_9\text{O}_4\text{-ONa}]_n$.

The alkali cellulose is then treated with carbon disulfide to form sodium cellulose xanthate



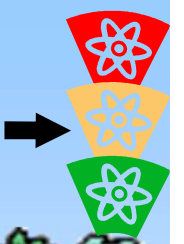
viscose

Rayon fiber is produced from the ripened solutions by treatment with a mineral acid, such as sulfuric acid. In this step, the xanthate groups are hydrolyzed to regenerate cellulose and release dithiocarbonic acid that later decomposes to carbon disulfide and water





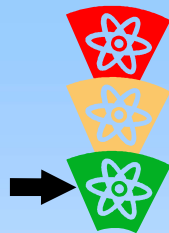
viscose



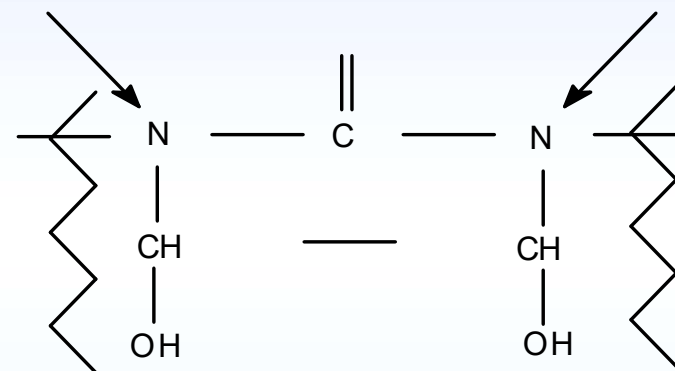
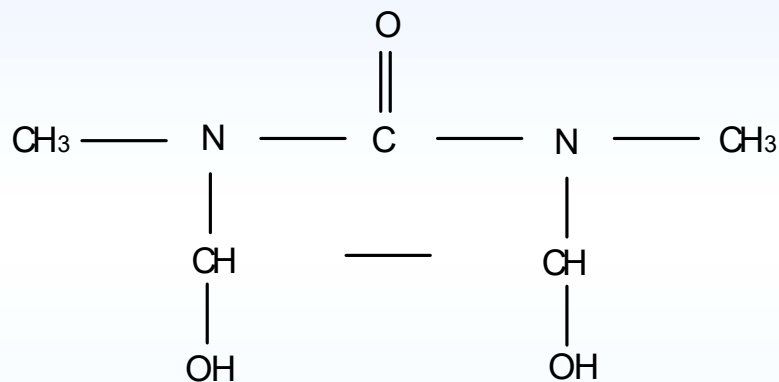
Viscose: Mr. Georges Audemars developed the first rayon fibre around 1855, but his method was impractical for commercial use. Hilaire de Chardonnet, Comte de Chardonnay, patented "Chardonnay silk" in 1884, but it was so flammable it had no safe use. Finally, in 1894, Charles Frederick Cross, Edward John Bevan, and Clayton Beadle patented the first safe and practical artificial silk, which they named "viscose"



Reactive chemicals on fibers / Quantification of nitrogen



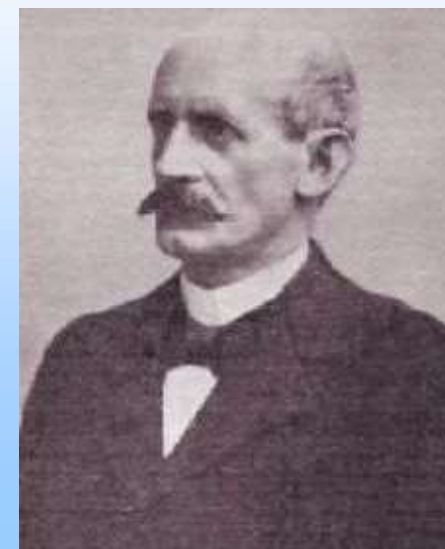
Chemical bond – extreme stability to extraction – necessary decomposition



**Principle: estimation of nitrogen after burning
/ashing**

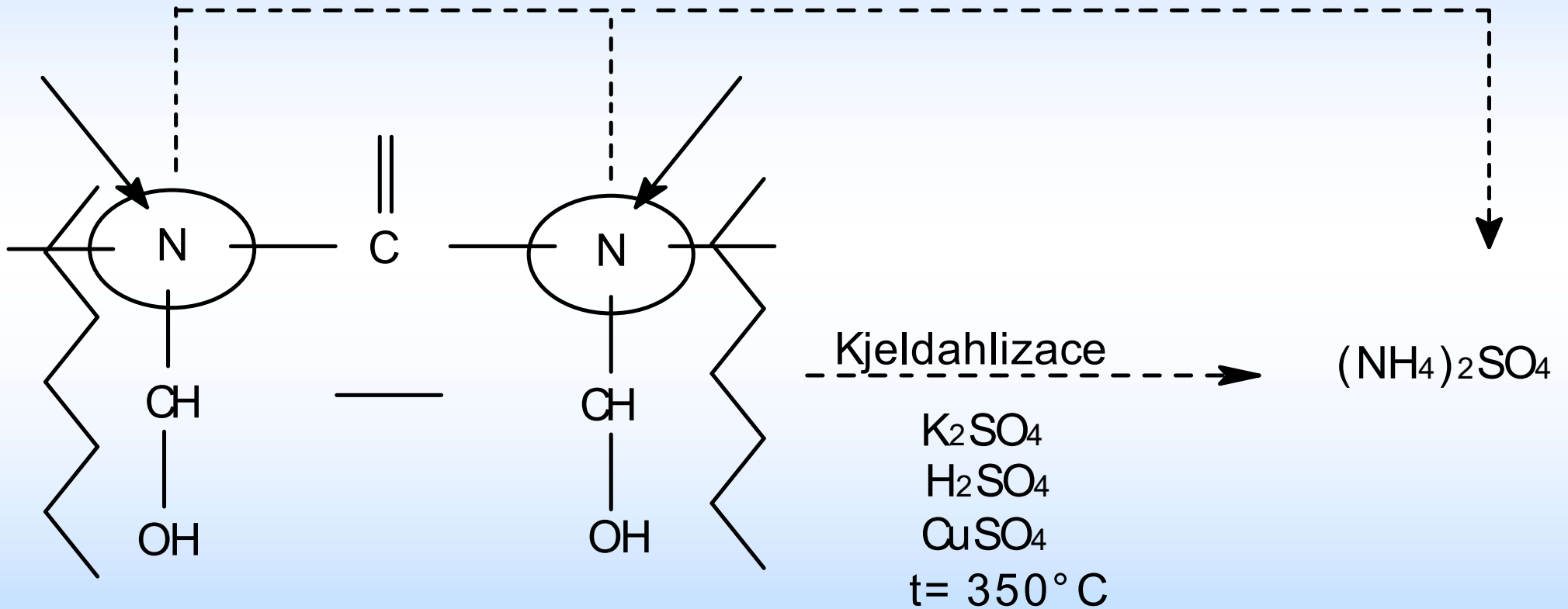
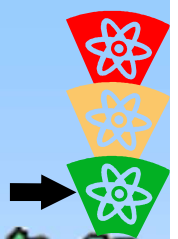
- by Kjeldahl method

Johan Kjeldahl - Danish chemist (1849–1900)



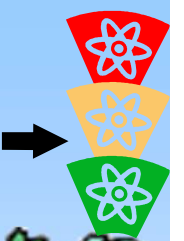


Quantification of nitrogen



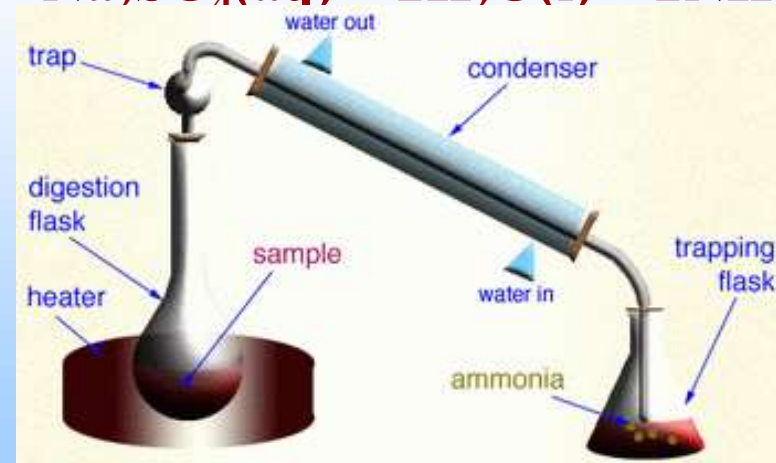


Quantification of nitrogen



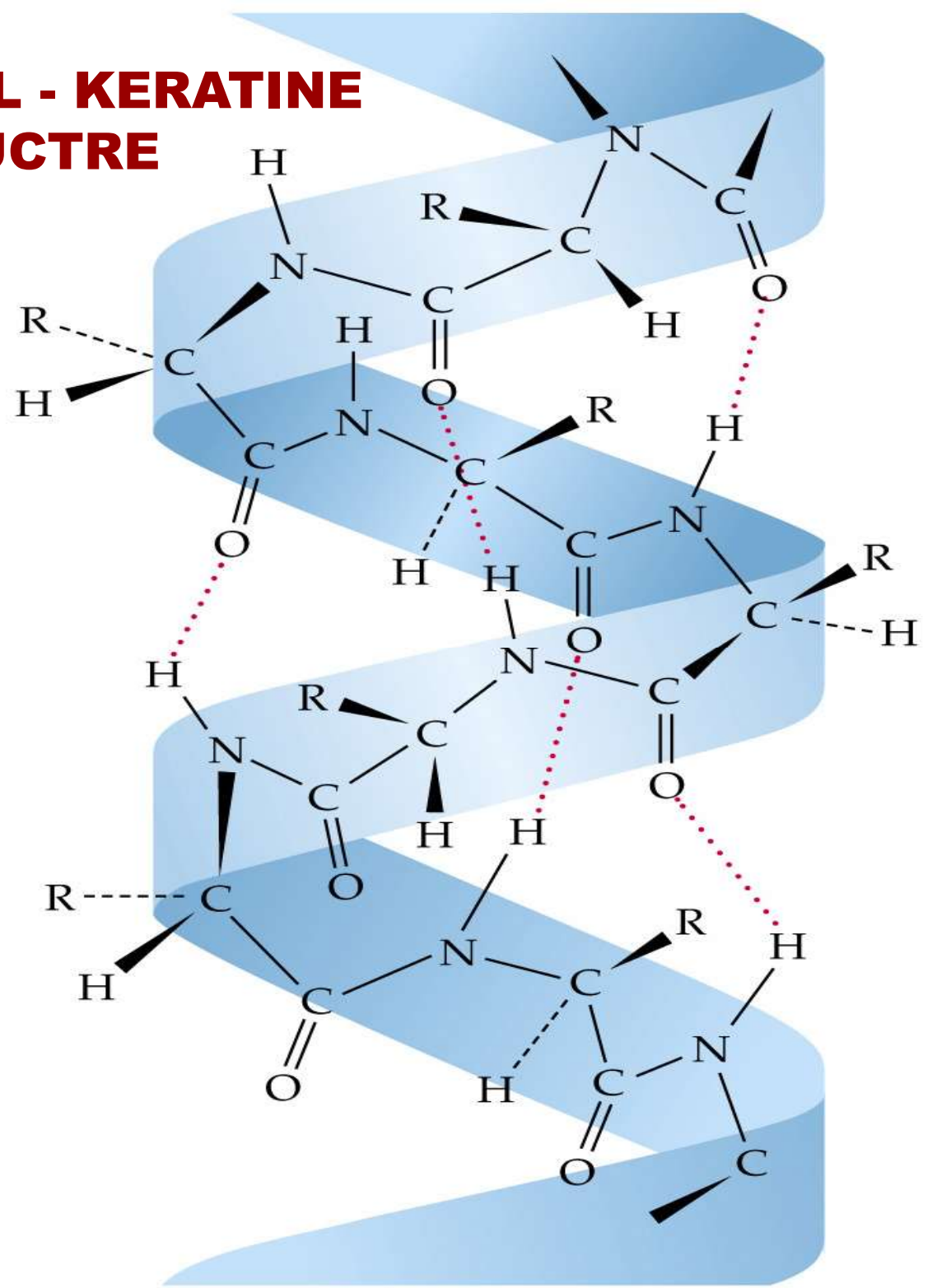
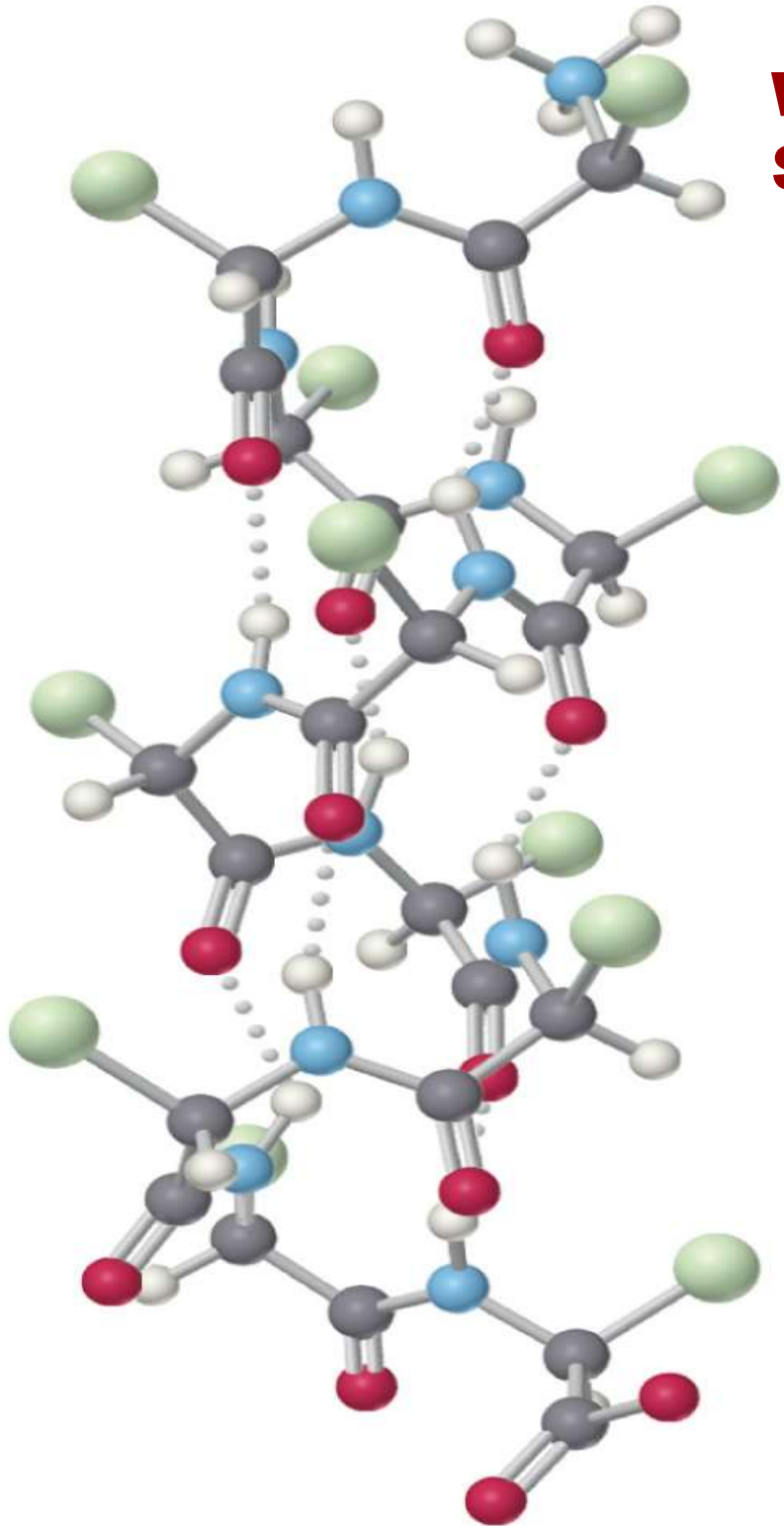
Total Kjeldahl Nitrogen or TKN is the sum of organic nitrogen; ammonia (NH_3) and ammonium (NH_4^+) in the chemical analysis of soil, water, or wastewater (e.g. sewage treatment plant effluent). To calculate Total Nitrogen (TN), the concentrations of nitrate-N and nitrite-N are determined and added to TKN.

Degradation:



Ammonia quantity is measured by pH titration in separated glass

WOOL - KERATINE STRUCTRE

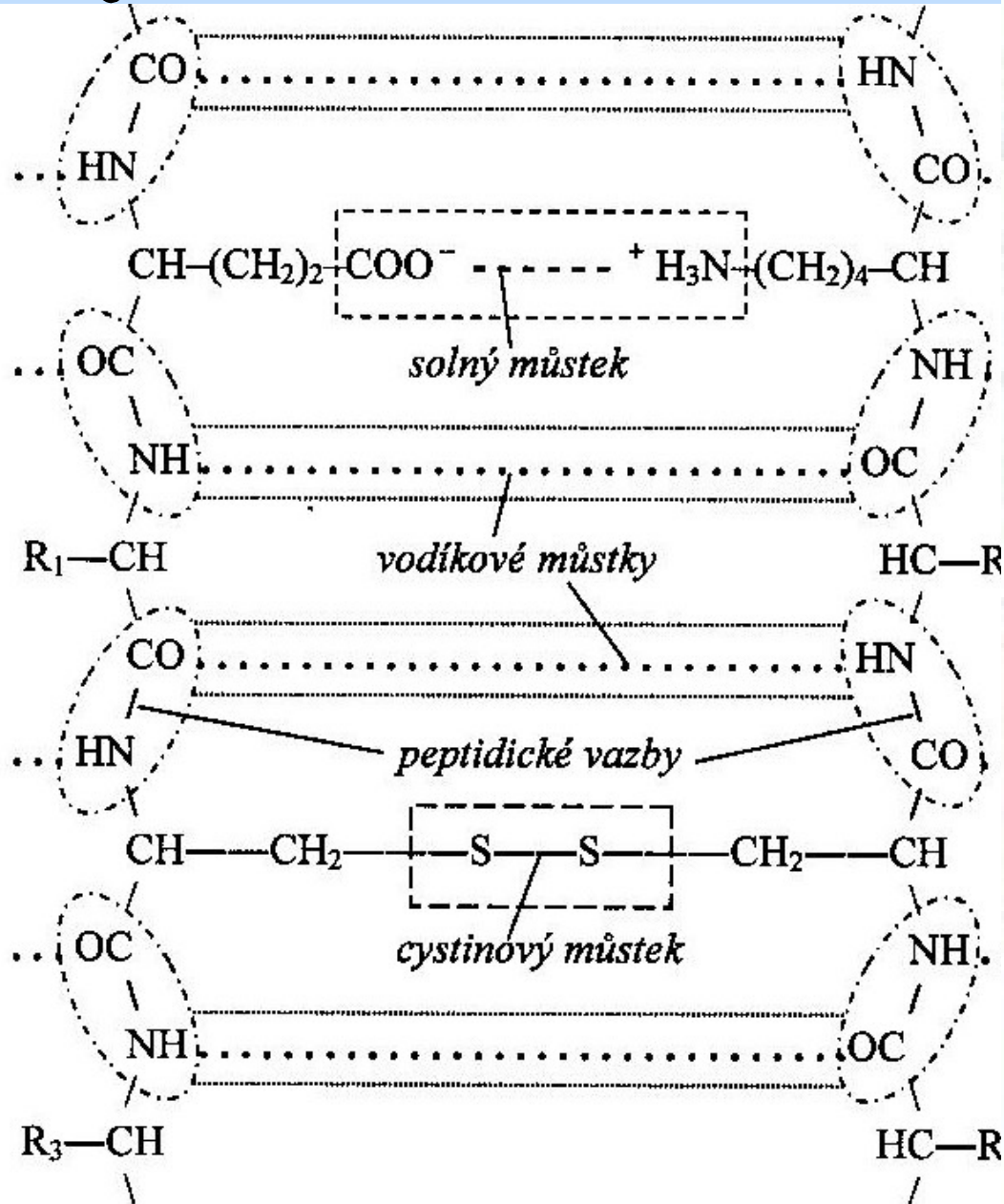




WOOL - KERATINE STRUCTRE

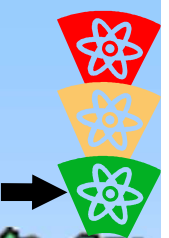


polypeptidický řetězec

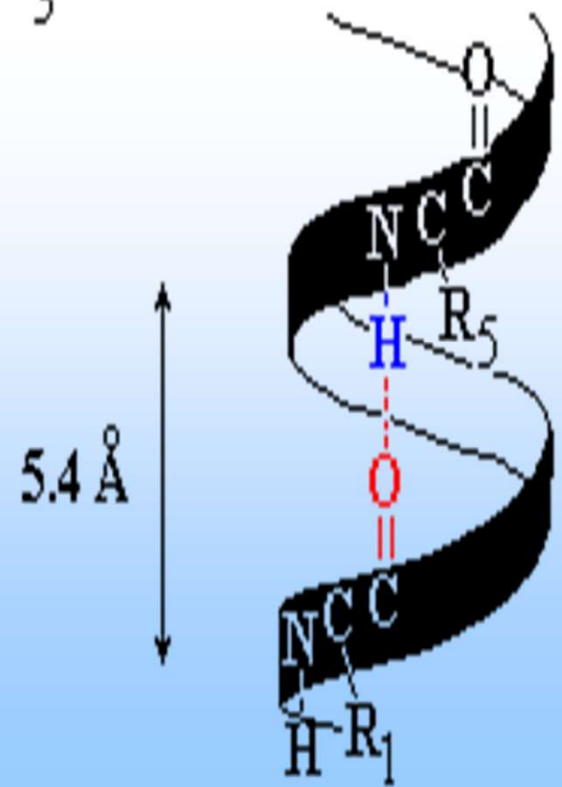
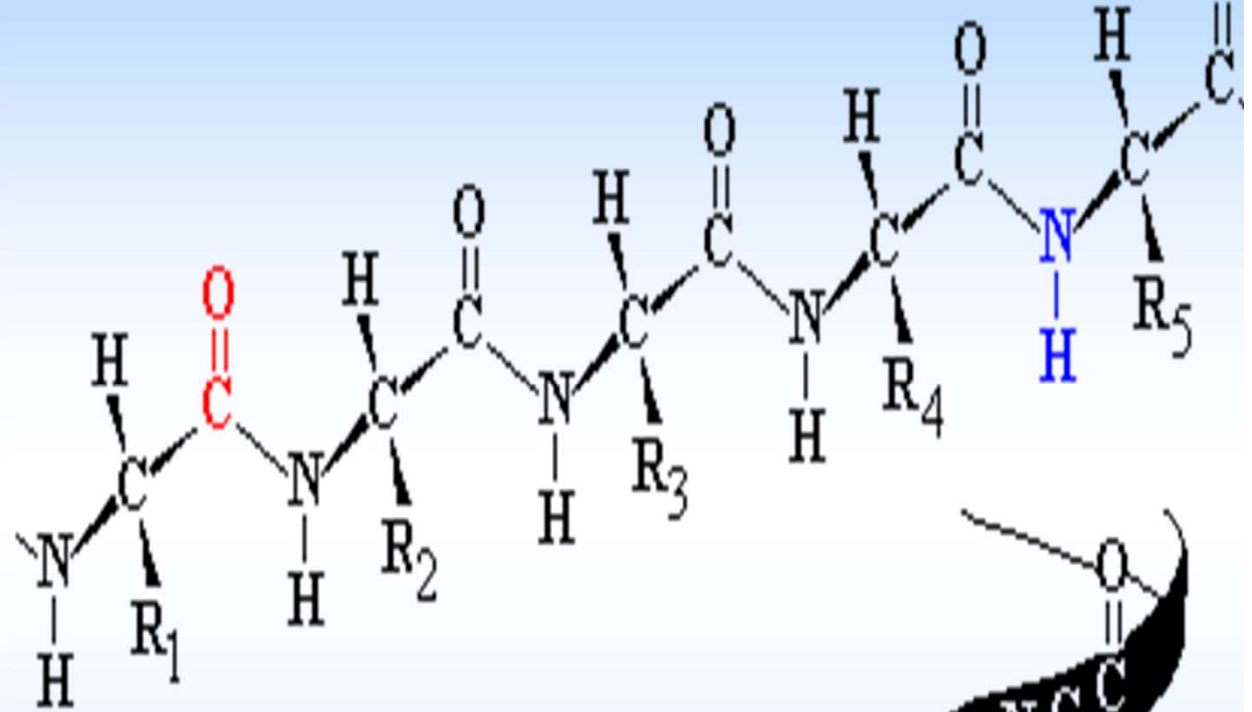
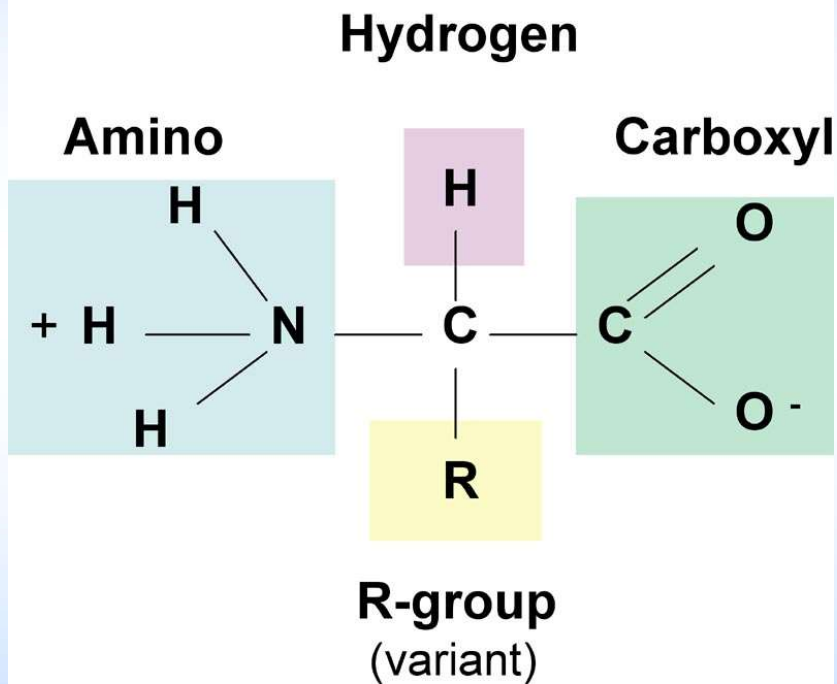




WOOL - KERATINE STRUCTRE

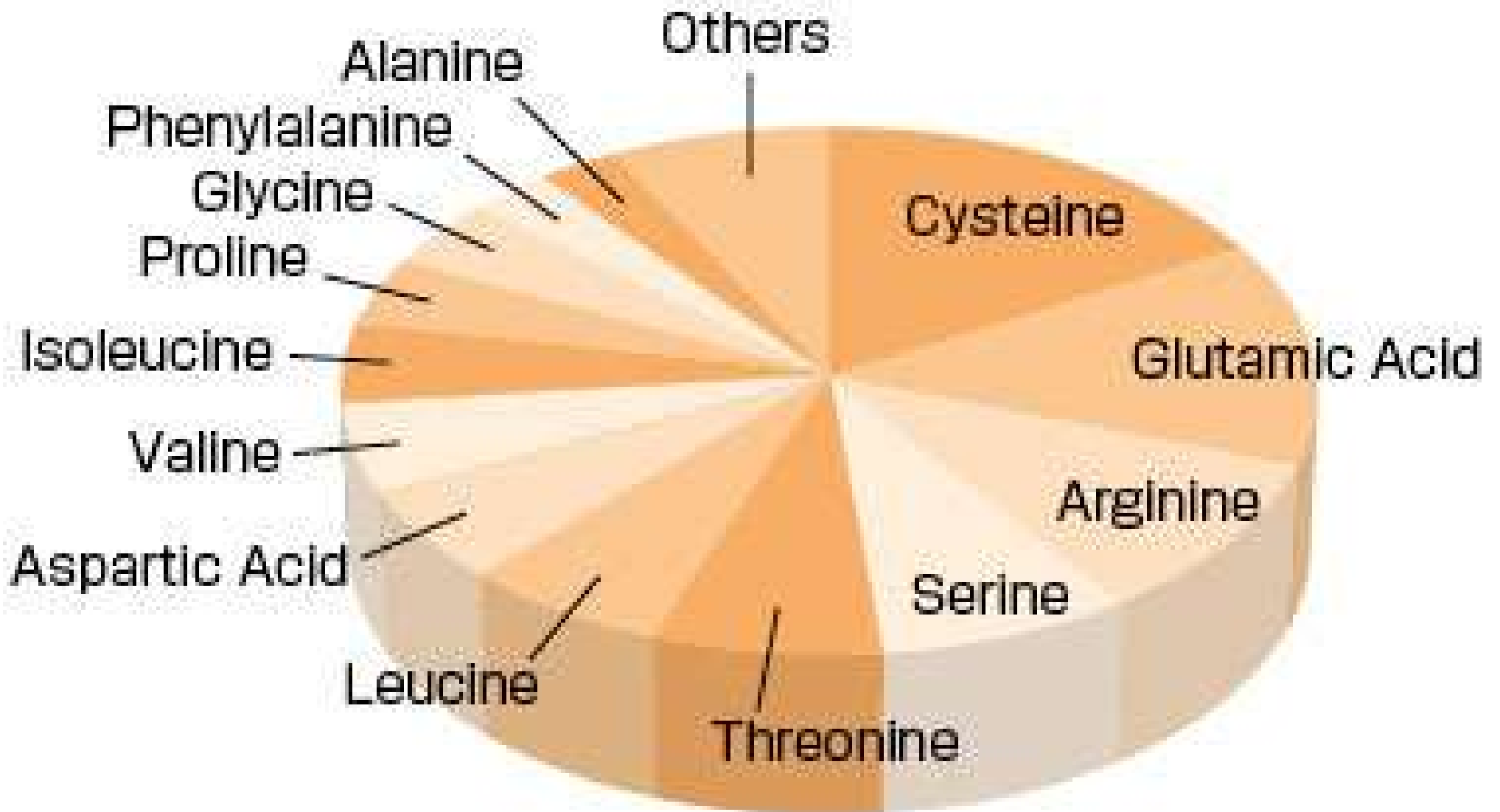
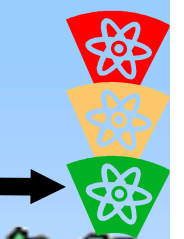


Amino Acid Structure





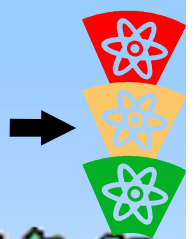
WOOL - KERATINE STRUCTRE





WOOL - KERATINE STRUCTRE

Aminoacids



Aminoacids are changed by chemical damage of wool – possible test of wool damage is based on wool aminoacids analyses

Aminoacids are in wool fibers in polymeric form (peptides)

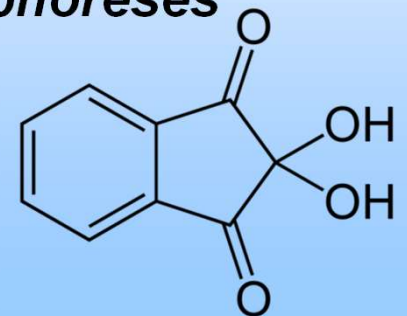
-For the analyses of aminoacids is necesery to separate aminoacids
By H₂SO₄ (10 hours, 105°C, 3M H₂SO₄)

$3M = ? \text{ g/liter}$ $1M=1\text{mol/liter}$ $1\text{mol of H}_2\text{SO}_4=98\text{g} (2 \times 1 + 1 \times 32 + 4 \times 16)$
 $3m=3 \times 98=294 \text{ g/litre}$

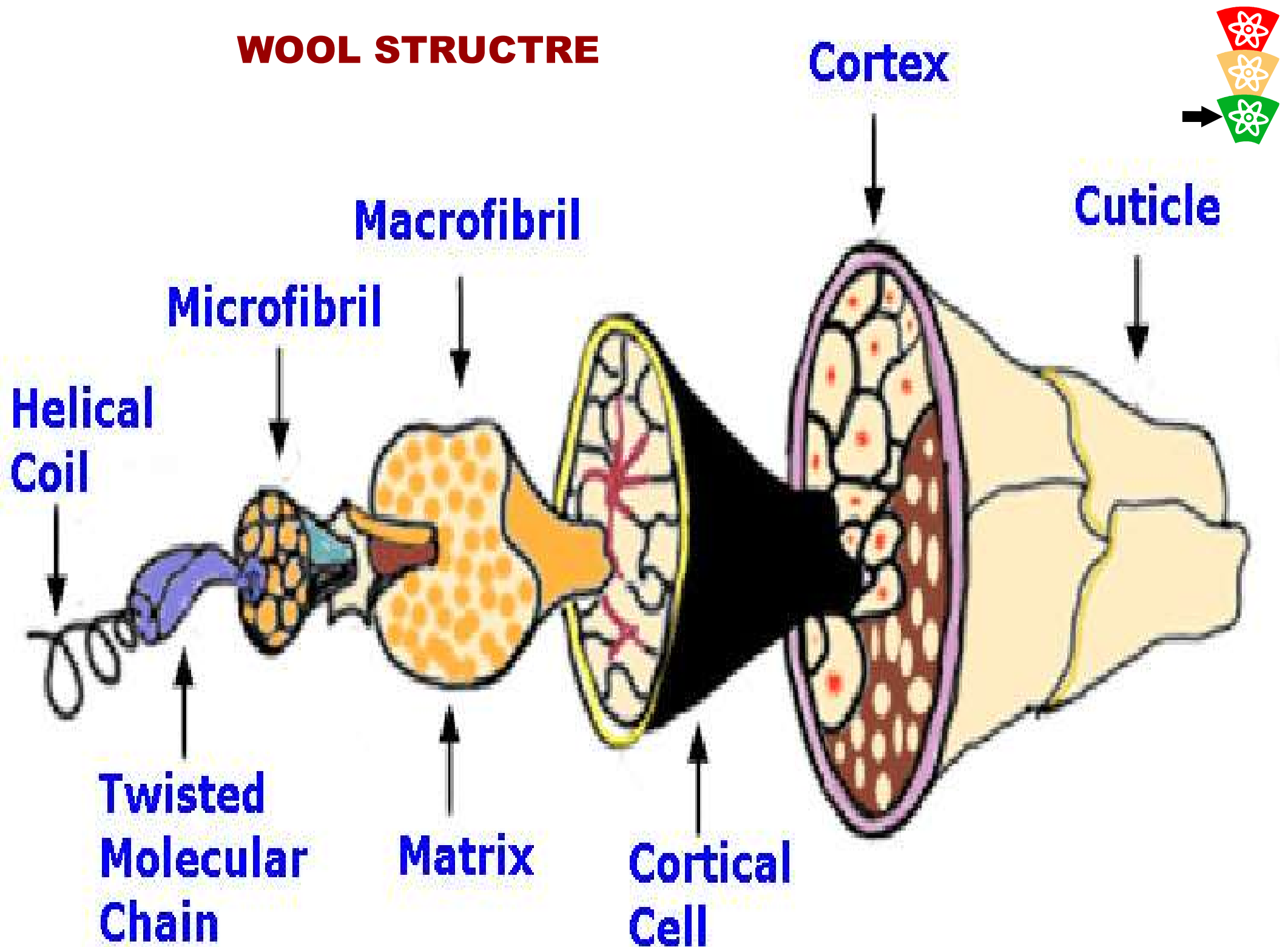
This procedure didnt change the concentration of aminoacids !!!

Analyses of aminoacids:

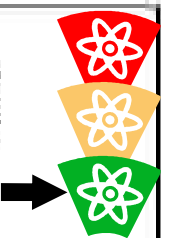
- *separation from the solution by chromatography or electrophoreses*
- *„colorratio“ of aminoacids by ninhydrin*



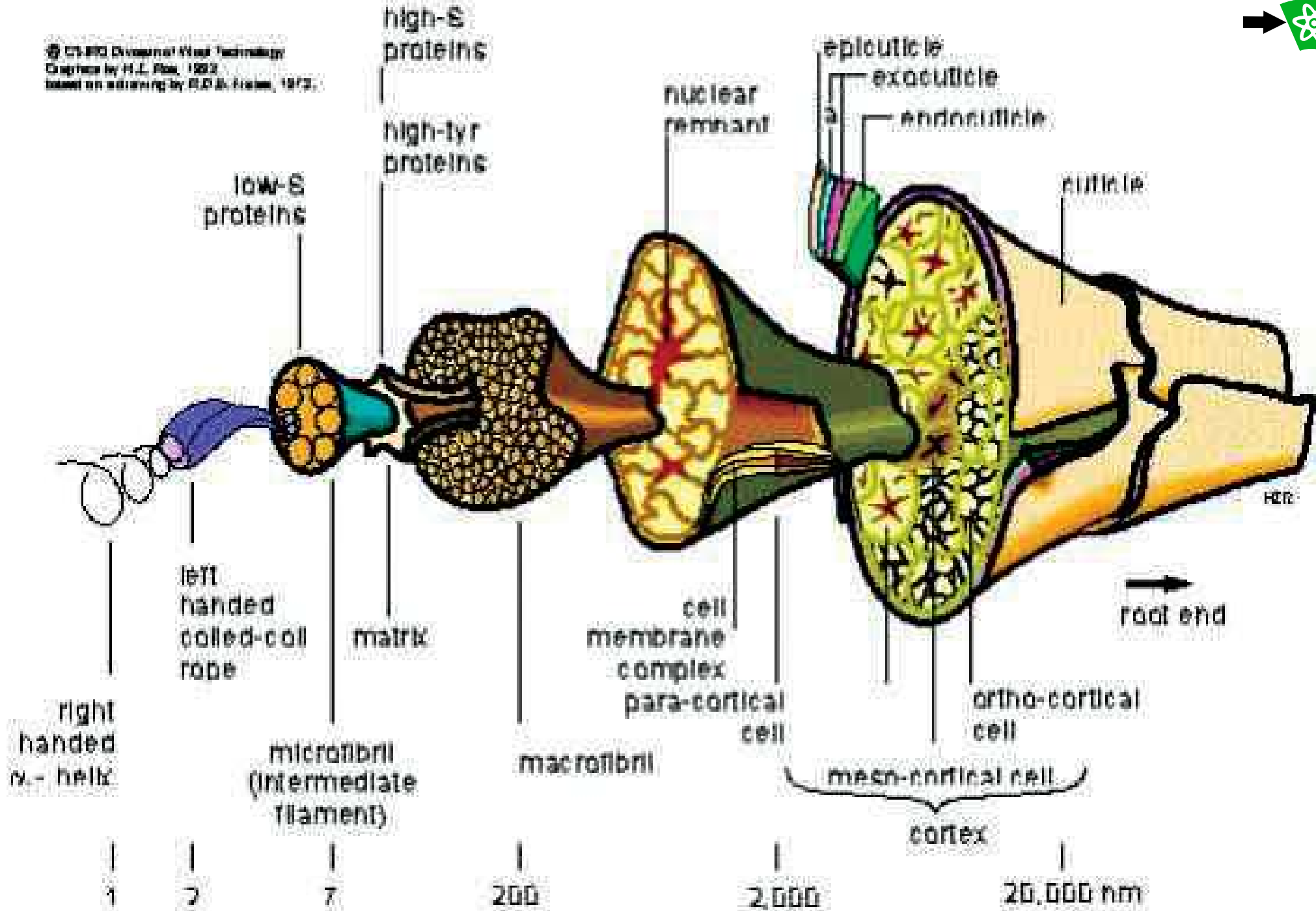
WOOL STRUCTRE

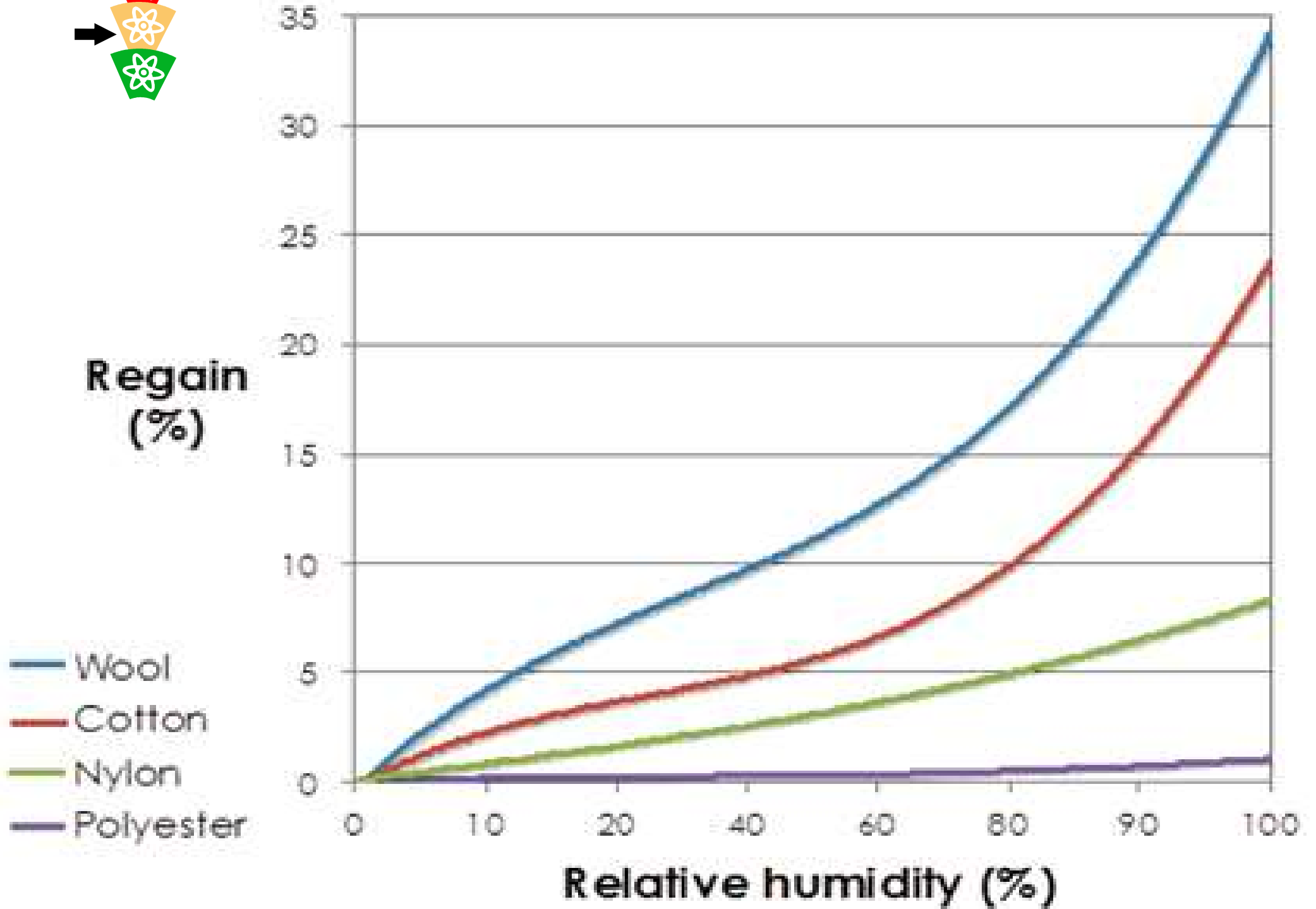
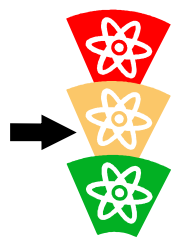


THE STRUCTURE OF A MERINO WOOL FIBRE



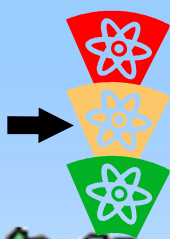
© CSIRO Division of Wool Technology
 Graphics by H.L. Potts, 1982
 based on drawing by R.D. & Frazer, 1973.



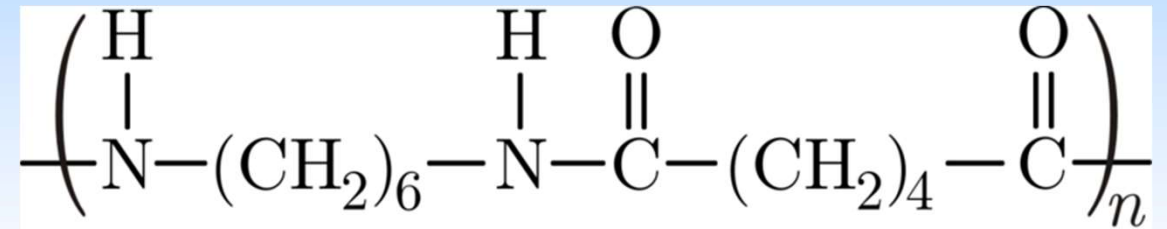




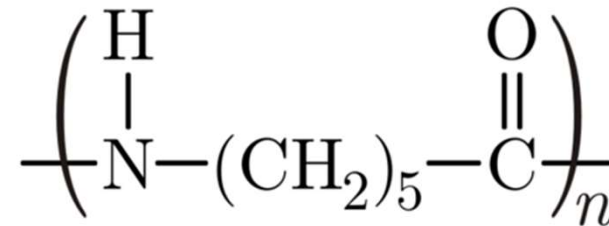
Polyamide (PA)



PA 6.6 (T_g, T_m... PA6+20°C),
PA 6.6 INSOLUBLE IN DMF

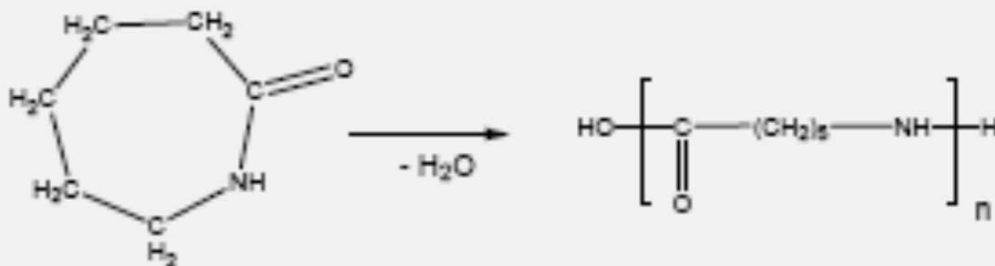


Nylon 66



Nylon 6

QUANTITY OF CARBONS (PA6)



ε-Caprolactam

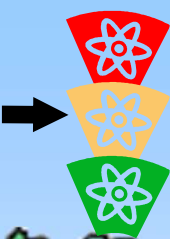
PA 6

n = 200

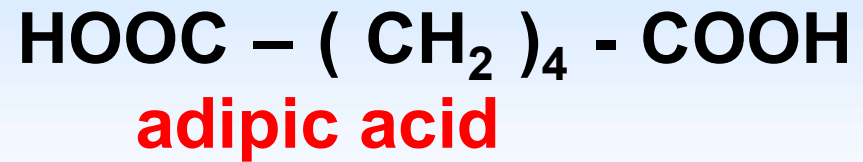
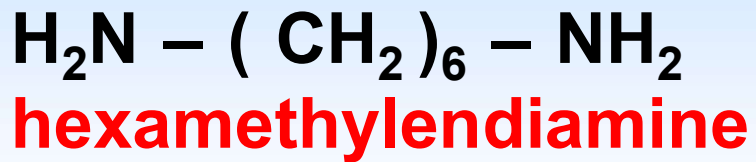
FROM Caprolaktam

T_m 220 °C

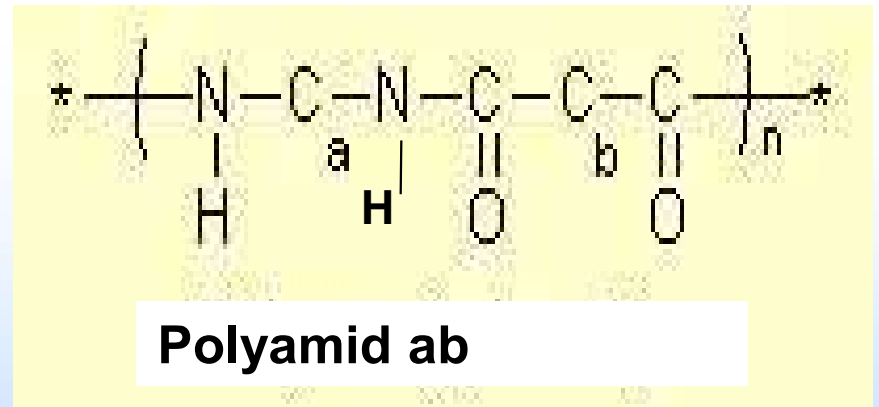
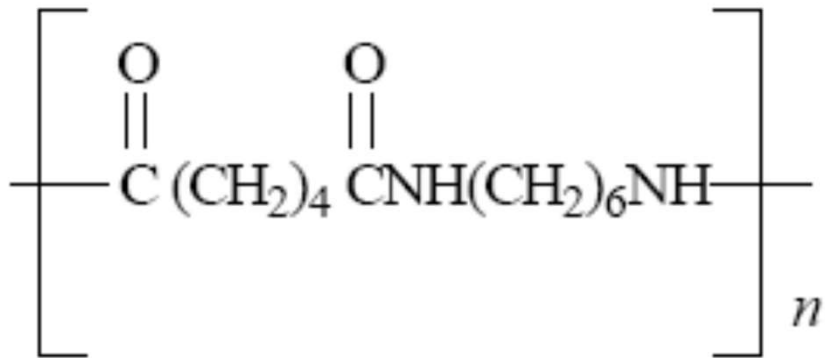
POLYAMIDE 6.6



Monomers



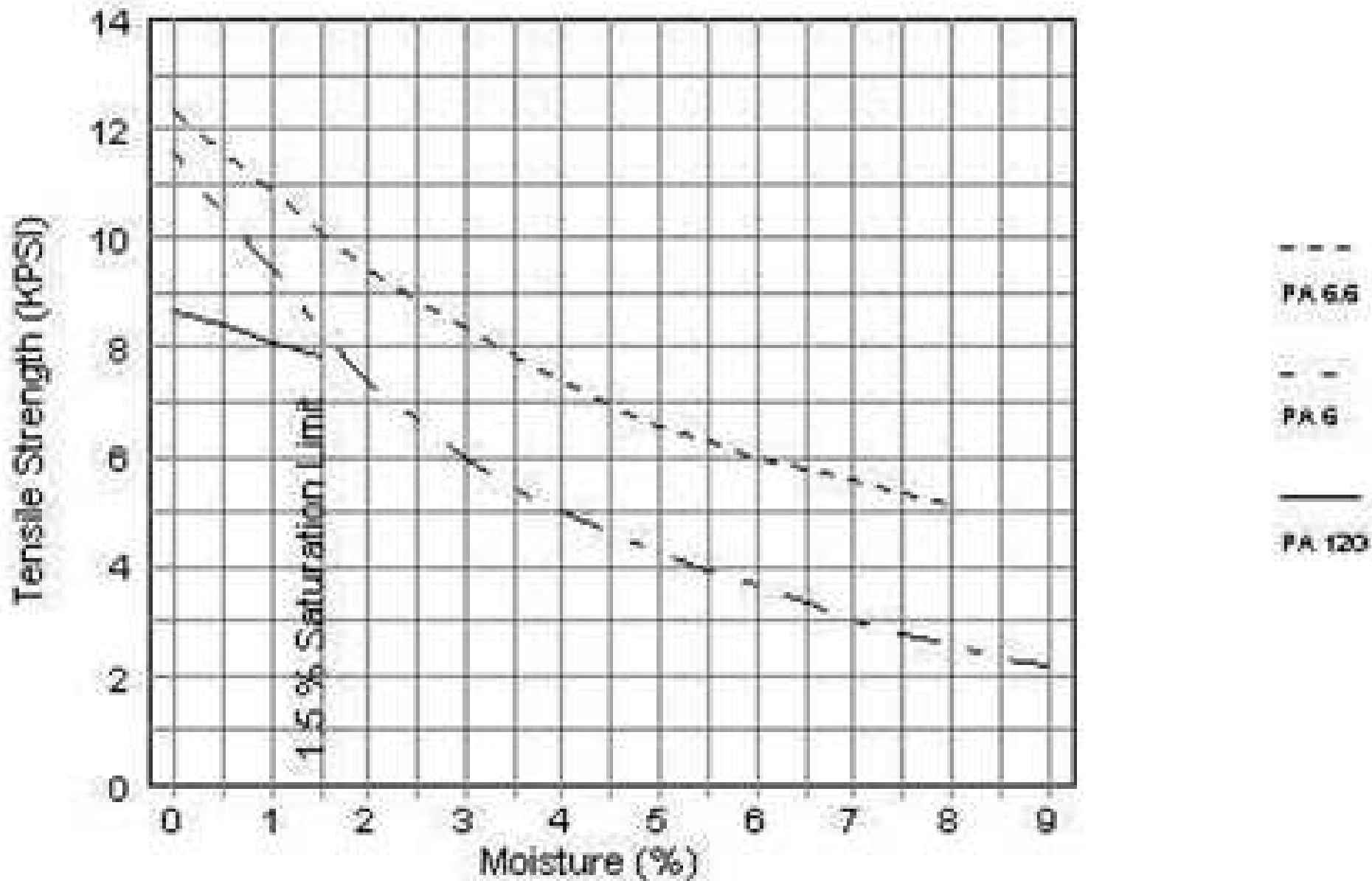
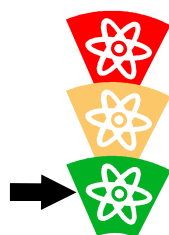
Polymer



T_m: 260 °C

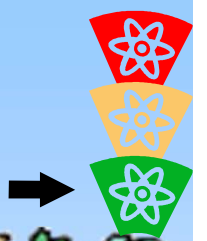
n= 50 - 80

Moisture Absorption vs. Tensile Strength





Polyamide



Thermal damage

- Typical by ironing or by flash
- Microscopic identification: melted fibers
- Temperature for ironing 160°C, melting point PA 6 - 215°C, PA 66 is it 260°C

Estimation based on viscosity of polymer solution (similar to cellulose)

Solvent: H₂SO₄ (95,6% - density 1,84g/cm³). 2 hours, 20°C – nondestructive damage – without light and oxygen

$$PPS = \left[\frac{248}{c} \cdot \sqrt{\frac{t}{t_0} - 1} \right] - 5$$

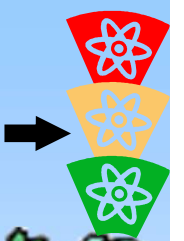
t ... Time of flow of solvent

t₀ ... Time of flow of polymer solution

c ... Polymer concentration in solvent [g/100ml]



Polymerization degree of PA



PA ... Different polymerization degree (according the production technology)

Important is the monomer quantity – high influence on polymerization degree

Example:

Unwashed PA 6 (7% of monomer): PPS =146

Washed PA 6 (monomer was wash off): PPS =170

After acid damage (boiling, 15 min, H₂SO₄ 10%): PPS= 112

Quantity of monomer can be estimated by extract in in hot water



Dyeing test for PA depolymerization



Acid damage – hydrolyses of PA

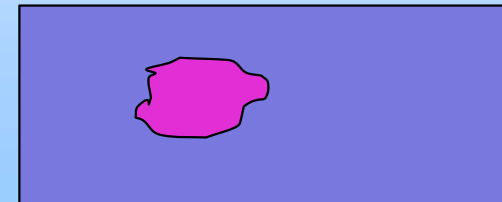
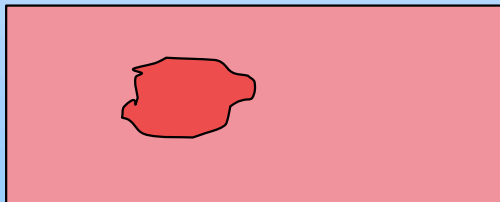
= increasing of NH_2 groups quantity – they are on the one end of polymer chain (on the second one is COOH)

Damaged PA is more dyeable by acid dyes in low acidic pH (in high acid: - NH_2 can be protonised and used for the dye sorption)

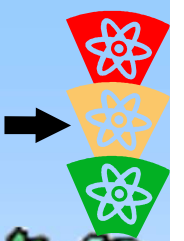
Damaged places – change of color deep (more and low red)

Dyeing with acidic and disperse dyes – color differences (red or violet) - The damaged places are more visible

(disperse dye sorption is not sensitive to polymerization degree)



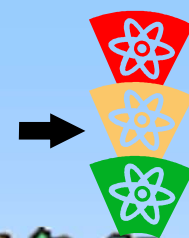
POLYESTER



Polyester is a category of polymers that contain the ester functional group in their main chain. As a specific material, it most commonly refers to a type called polyethylene terephthalate (PET).



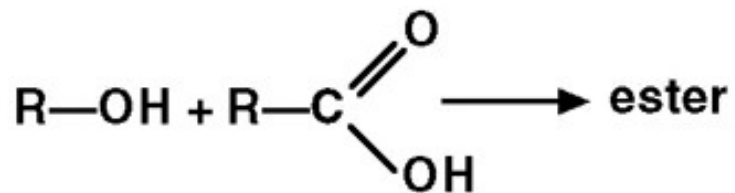
POLYESTER



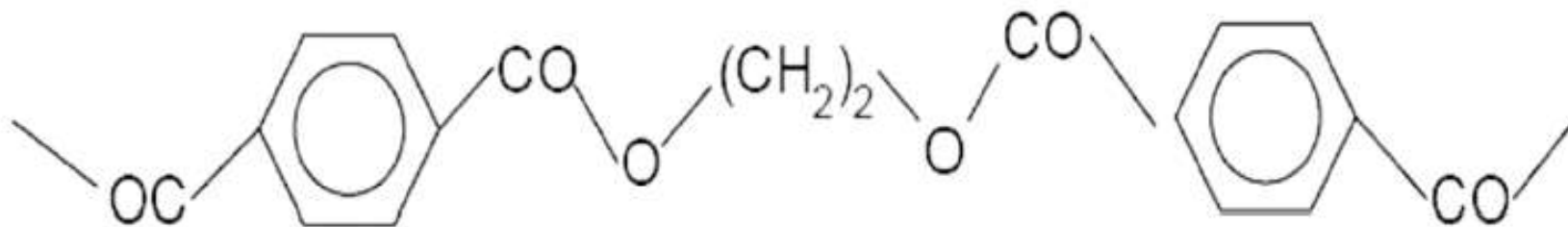
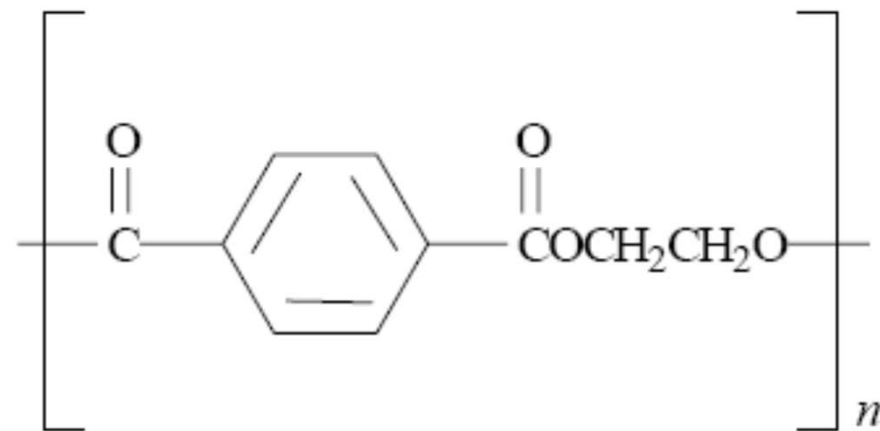
Polyethylentereftalát

$T_g = 70 - 80 \text{ } ^\circ\text{C}$

$T_m = 260 \text{ } ^\circ\text{C}$

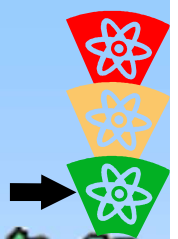


(R is any hydrocarbon chemical group)





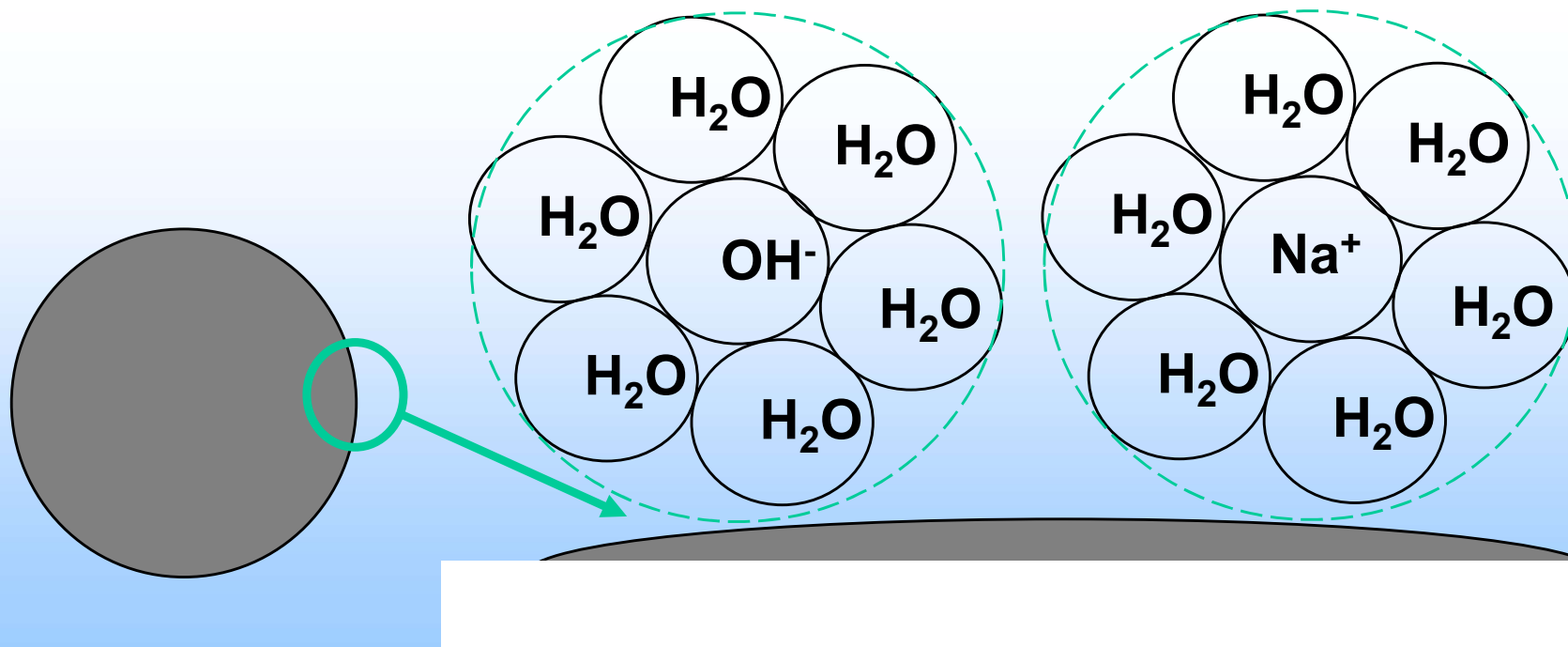
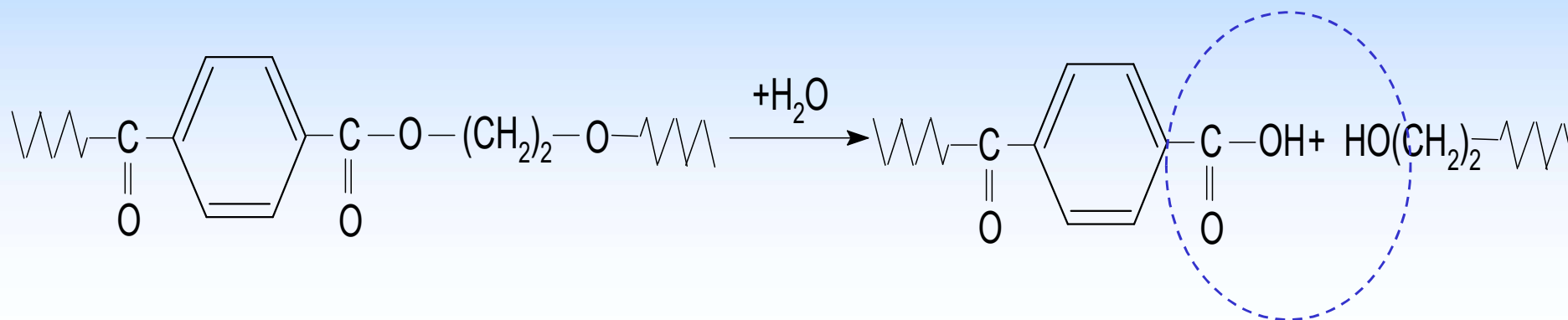
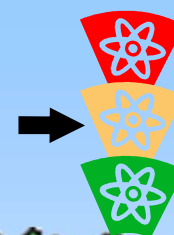
Alkaline hydrolysis - PET

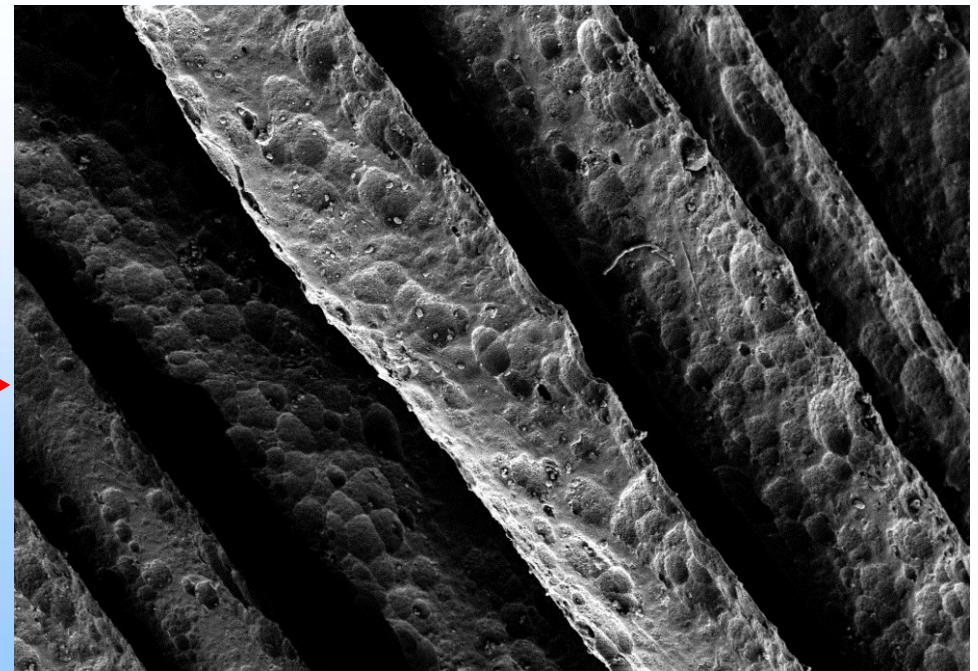
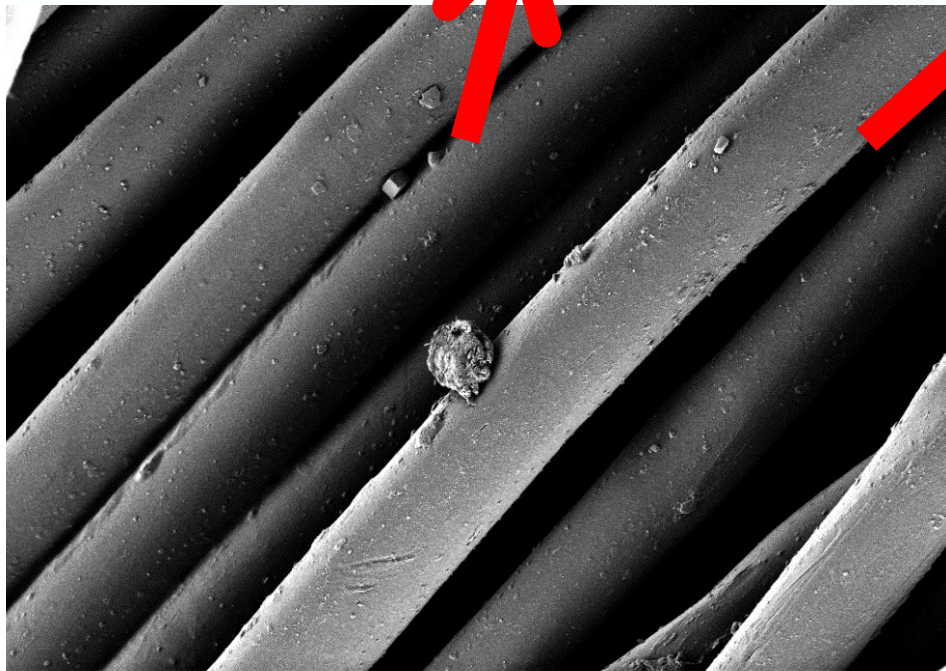
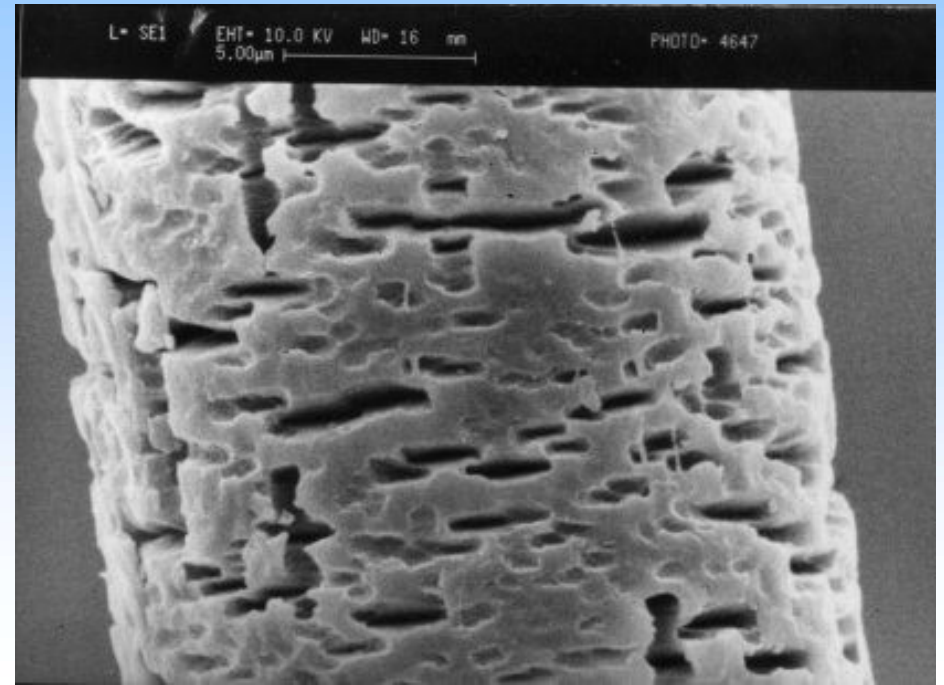
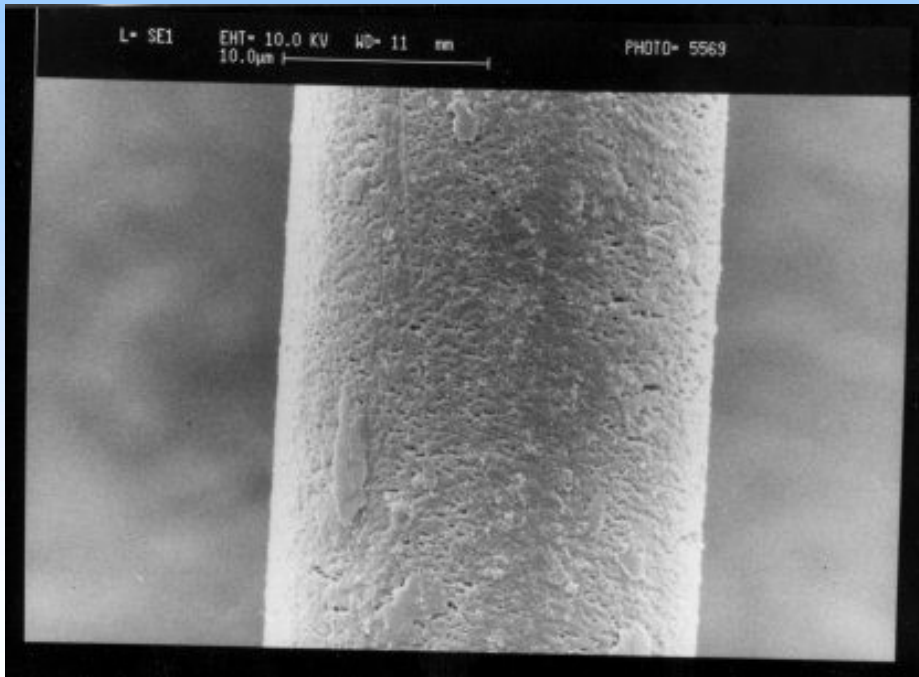


In 1952 Hall and Whinfield reported that the effect of alkali on PET was to improve the handle of textiles; since then numerous attempts have been made to understand this subject. This alkaline hydrolysis has several advantages in the apparel industry, in that it produces light weight materials without using light weight yarns which reduces the cost of production and it also gives surface modification of the fibres. Such alkaline sensitivity of polyesters is also useful in countering the problem of cyclic trimer deposition during the high pressure dyeing of the fibres by using a small amount of alkali in the dye bath which hydrolyses this trimer



Alkaline hydrolysis PET



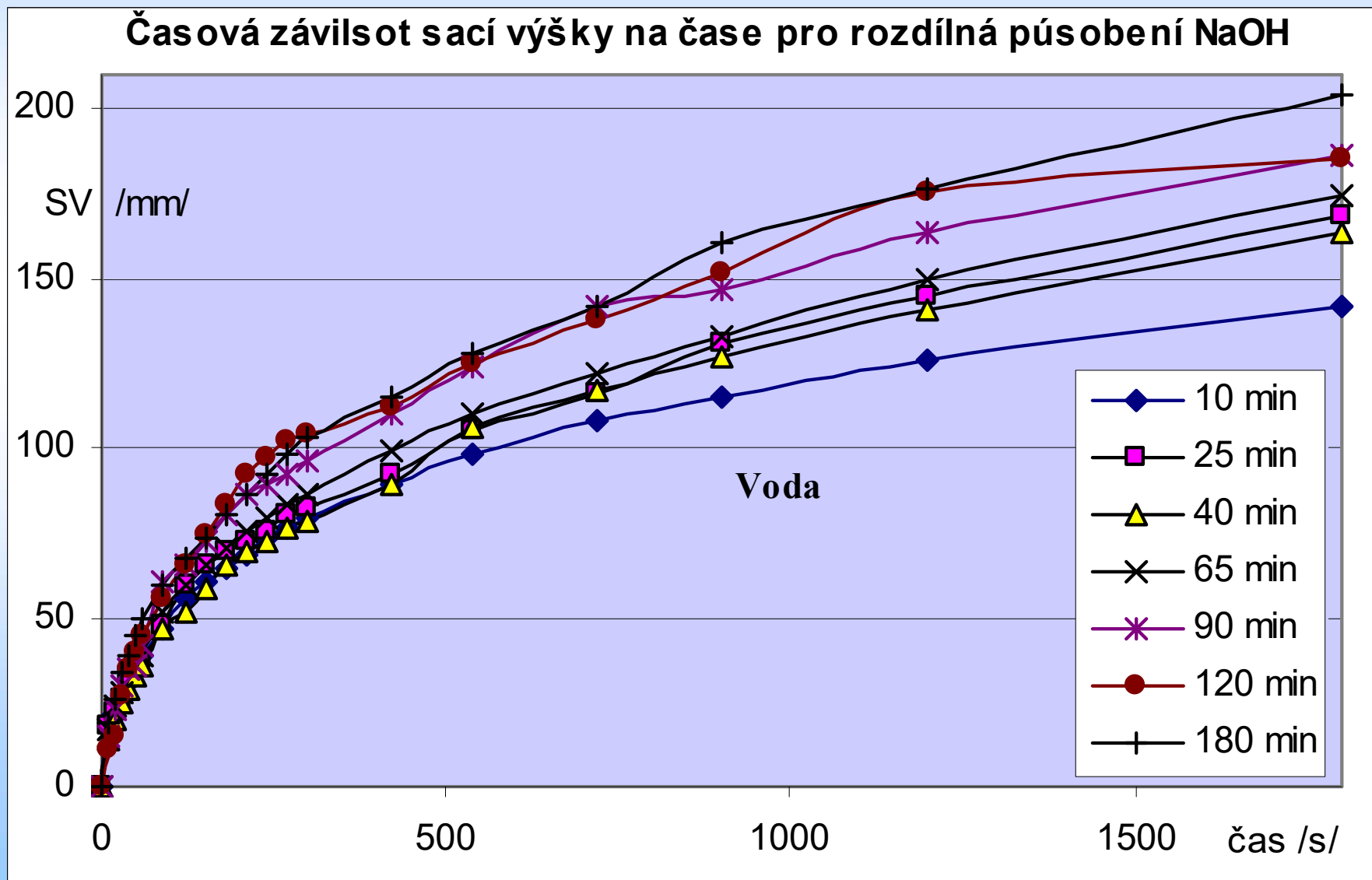
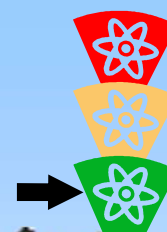


EHT = 2.50 kV Mag = 1.00 K X Scan Speed = 5 LAM, CXI, TUL
WD = 5.8 mm Signal A = SE2 Date: 18 Jun 2014 Lukas Volesky ZEISS

EHT = 2.50 kV Mag = 2.50 K X Scan Speed = 5 LAM, CXI, TUL
WD = 5.7 mm Signal A = SE2 Date: 18 Jun 2014 Lukas Volesky ZEISS

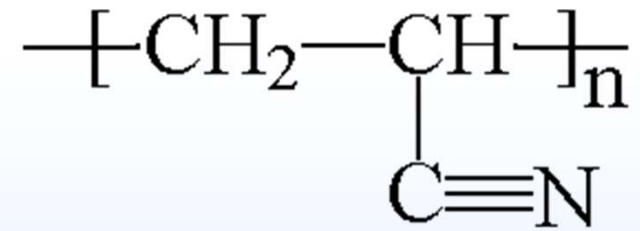
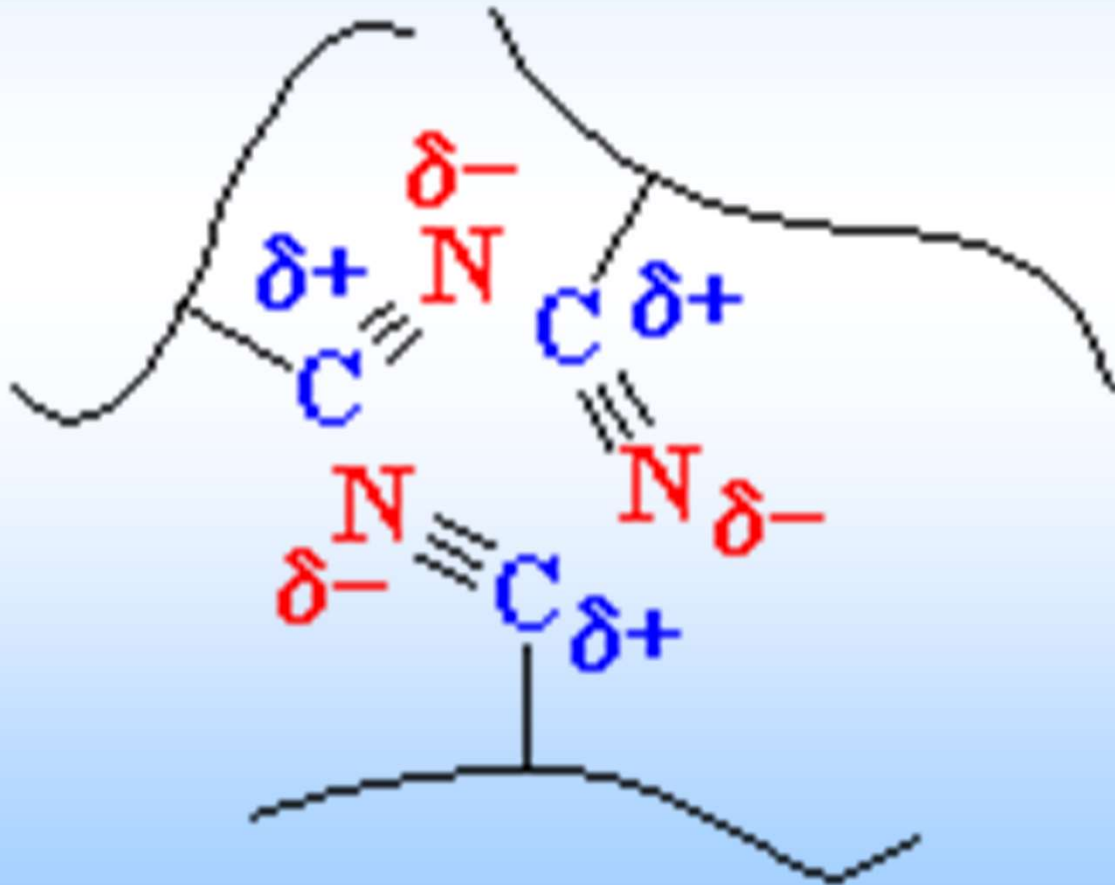
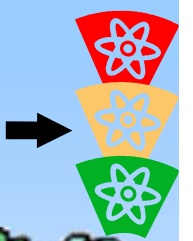


Alkaline hydrolysis - PET





Acrylic fibers

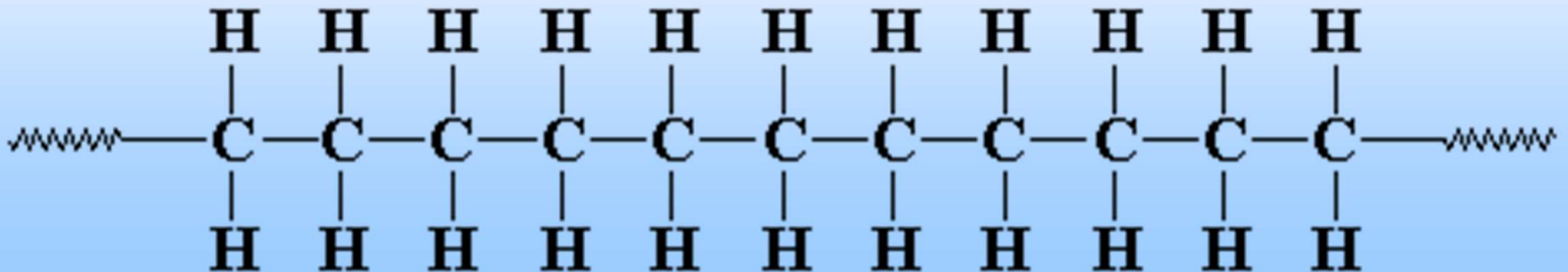
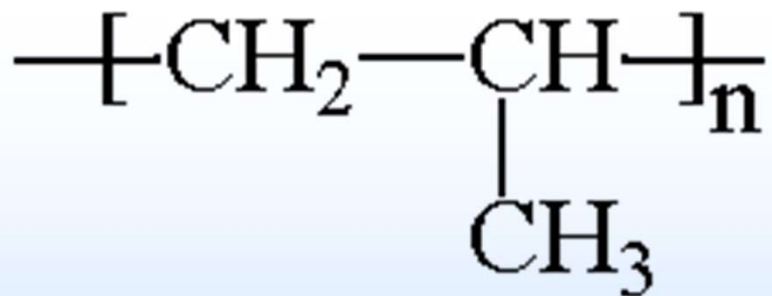
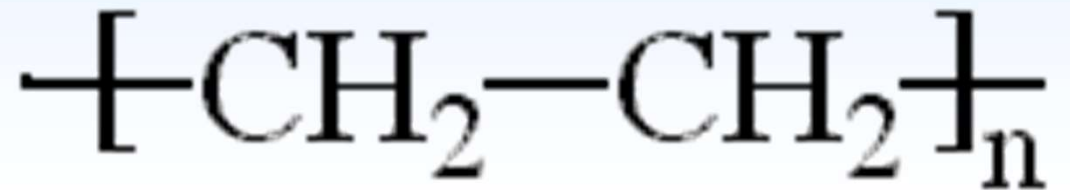


POLYOLEFINs



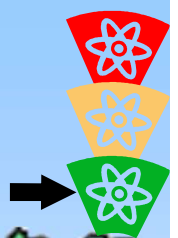
PE 0,95–0,96 g/cm³

PP 0,90–0,91 g/cm³

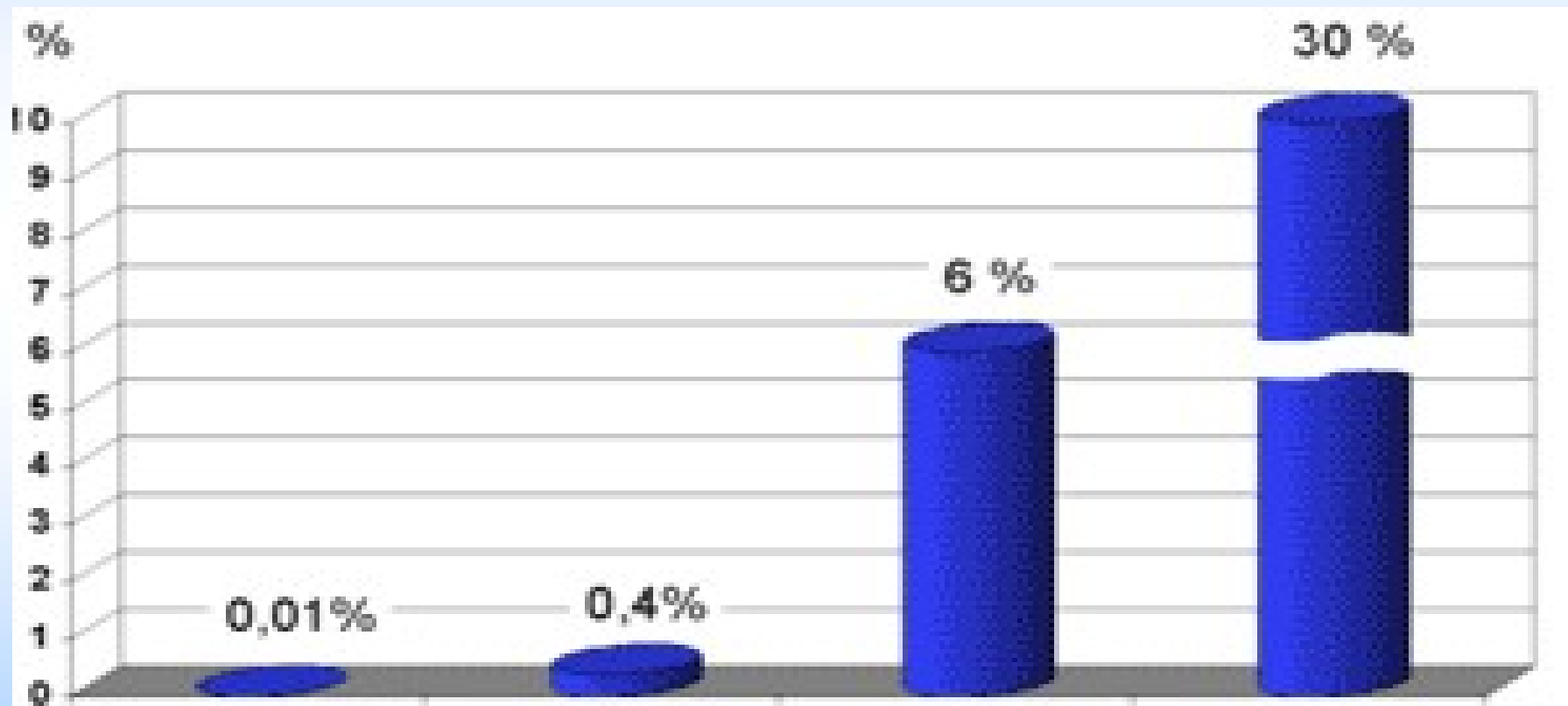




POLYOLEFINs



water



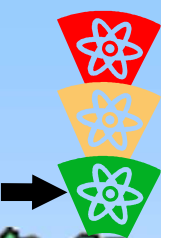
polypropylene

polyester

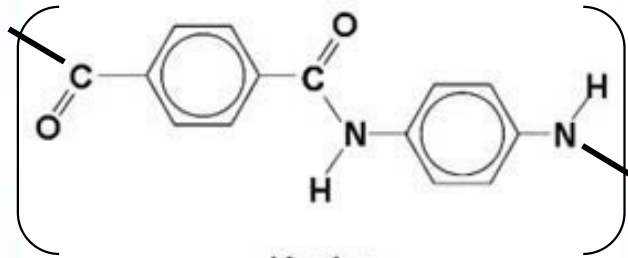
polyamide

wool

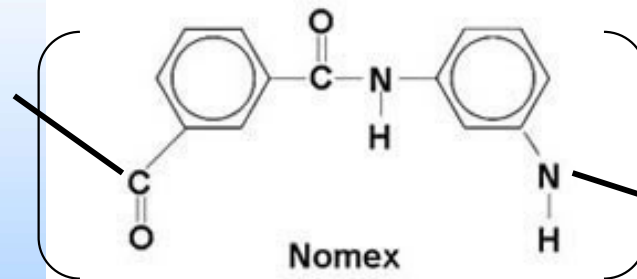
New fibers



**glass, teflon, kevlar,
nomex...**



Kevlar



Nomex

