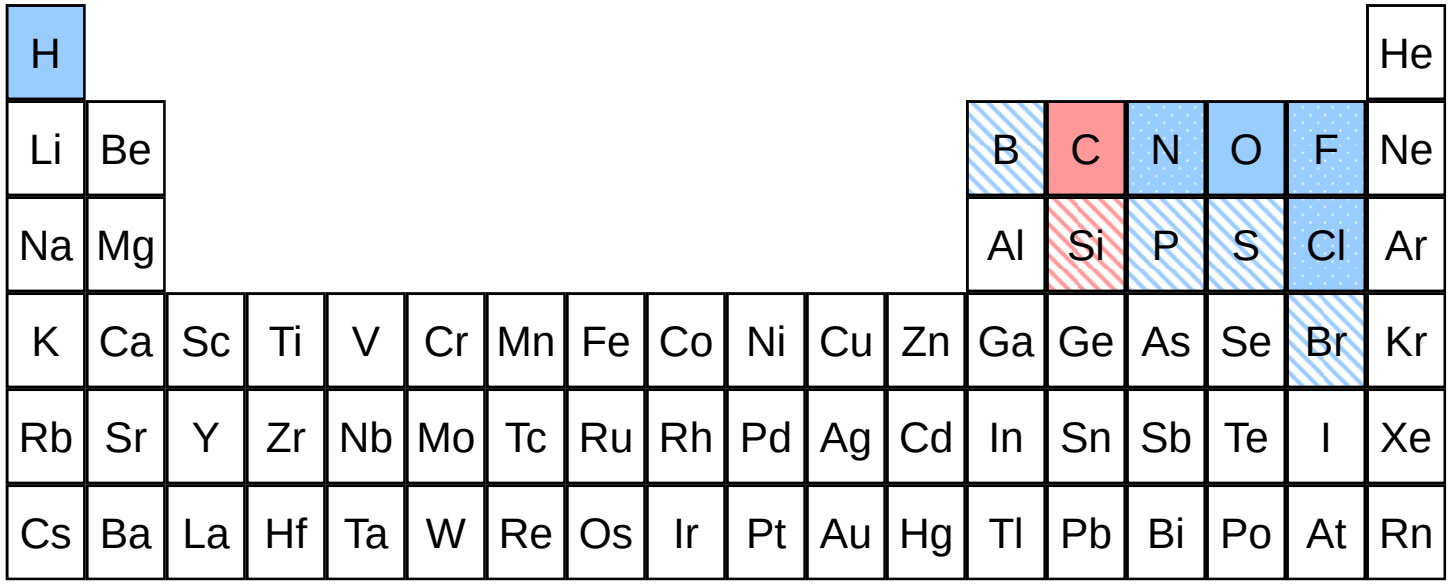
common properties of polymers

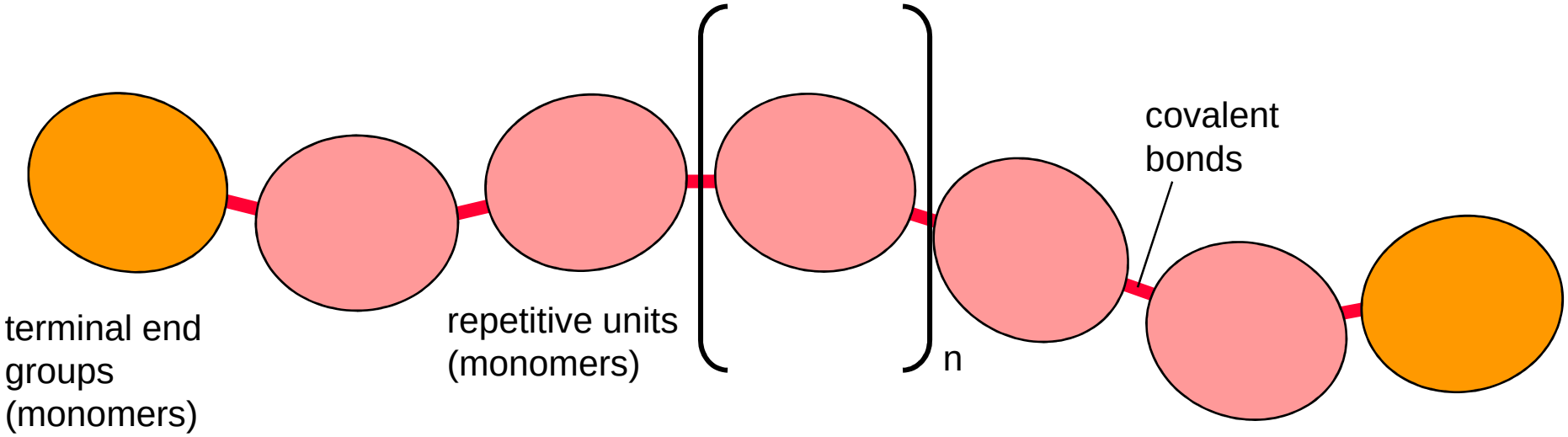
physical properties:	- usually whitish to yellowish optical appearance, in some cases transparent - usually low electrical and thermal conductivity - properties depend on the degree of polymerization
chemical properties:	- stable against diluted acids and bases - relatively stable against corrosion - decompose at higher temperature - may dissolve in organic solvent

typical elements in polymers



general structure of polymers:

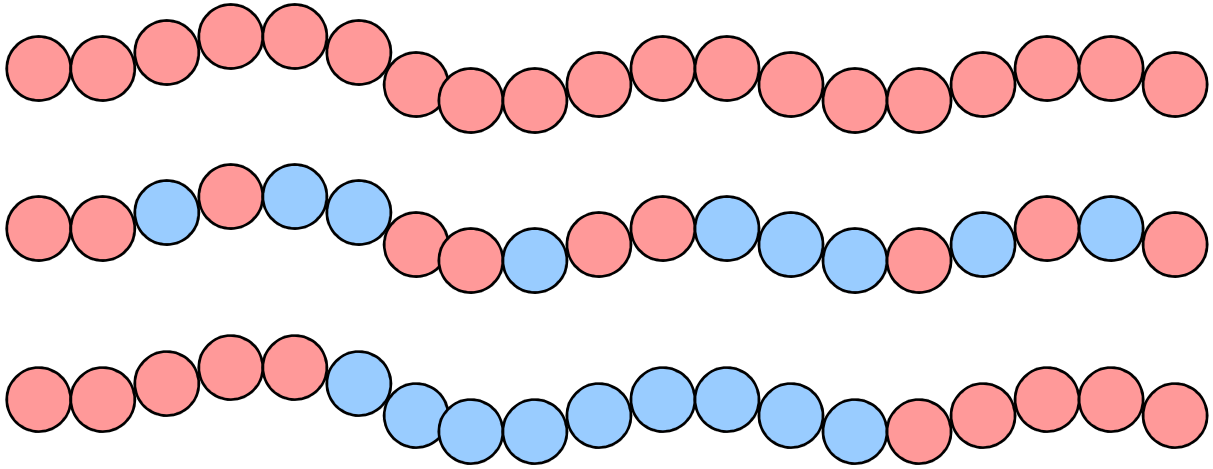
large number of monomers
linked by covalent bonds



number of monomer units = degree of polymerization

structural variations:

a) thermoplasts (will melt under increased temperature)

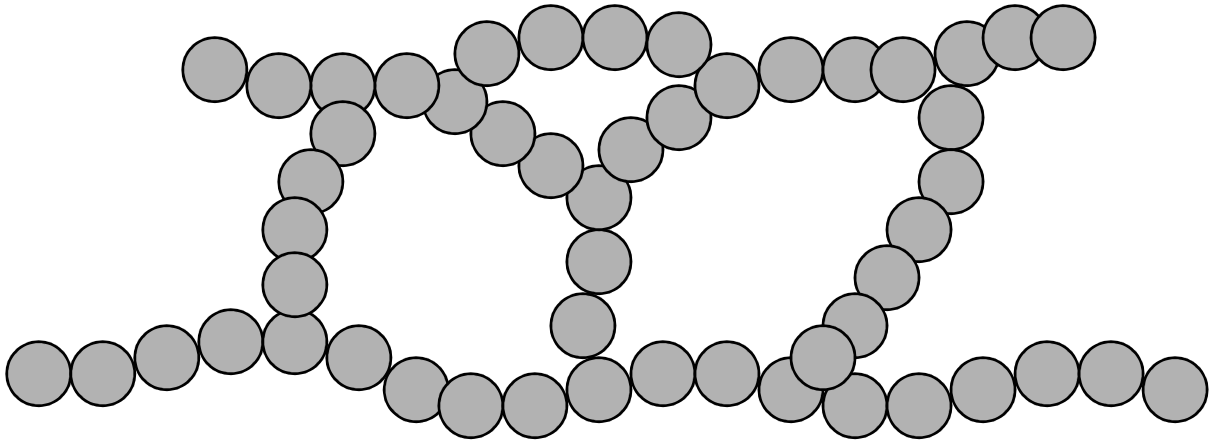


homopolymer

statistical copolymer

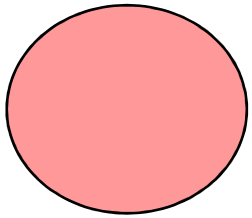
block-copolymer

b) thermosets (will not melt, but decompose at high T)



cross-linked polymer

important classes of polymers



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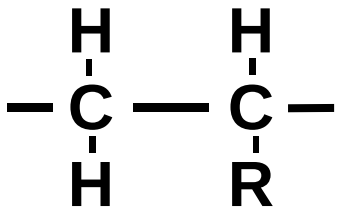
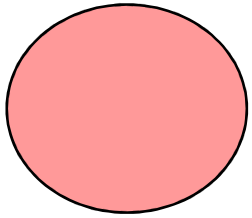


polyolefin



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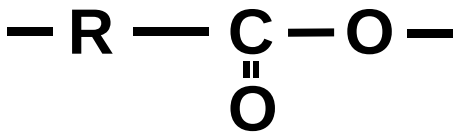
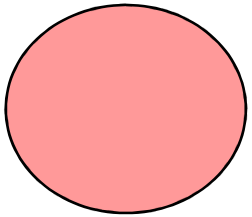


polyester



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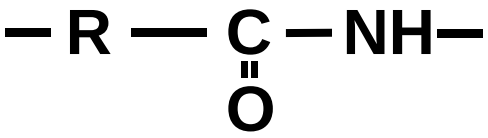
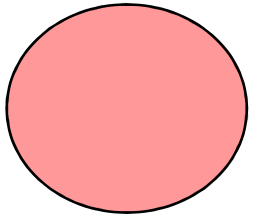


polyamide

R = variable chemical residue

types of polymers: polyolefins



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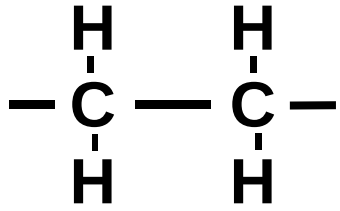
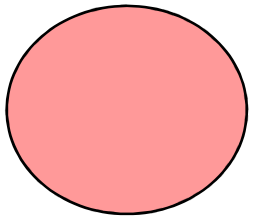


polyethylene **(PE)**



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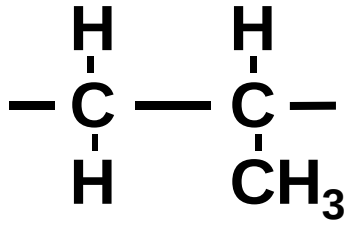
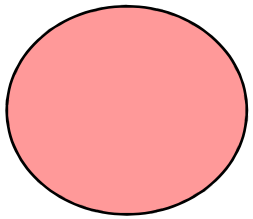


polypropylene **(PP)**



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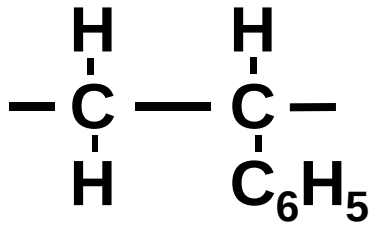
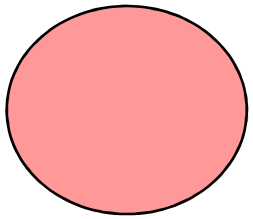


polystyrene **(PS)**



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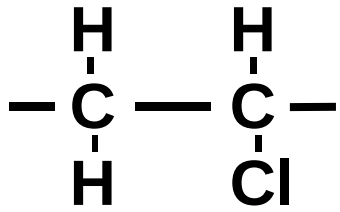
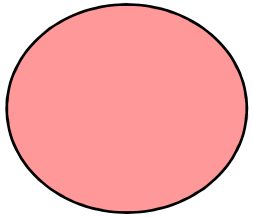


polyvinylchloride **(PVC)**

types of polymers: polyolefins



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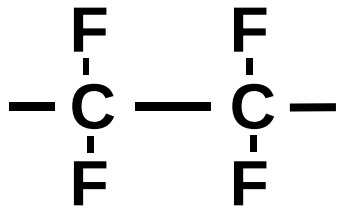
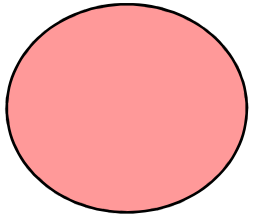


polytetrafluor-ethylene (Teflon®) **(PTFE)**



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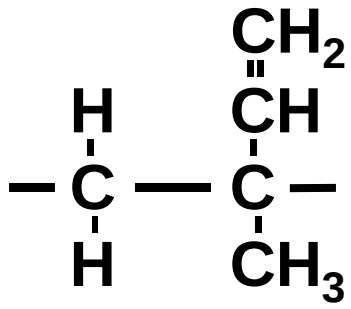


polyisoprene („rubber“)

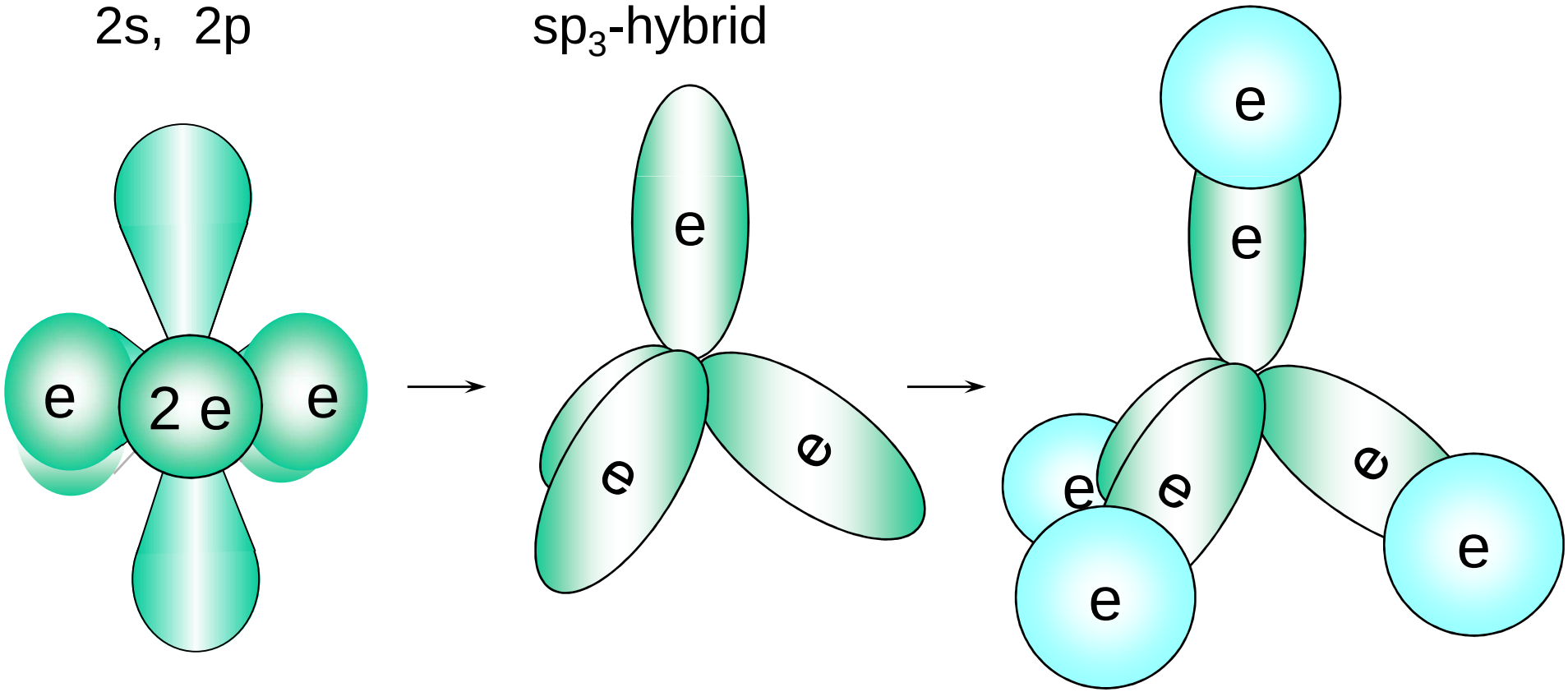
The additional double bond in the side group may take part in the polymerization which leads to a cross-linked polymer structure.

covalent bonds in hydrocarbons

carbon:
2s, 2p

hybridized carbon:
sp_3-hybrid

methane CH_4:

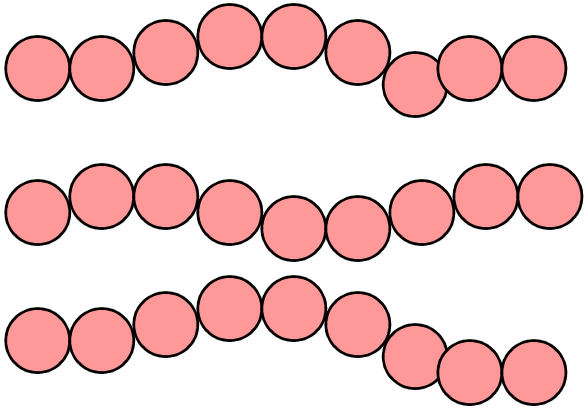


tetrahedron, bond angle 109°

common properties of polymers

physical properties:	- usually whitish to yellowish optical appearance, in some cases transparent - usually low electrical and thermal conductivity - properties depend on the degree of polymerization
chemical properties:	- stable against diluted acids and bases - relatively stable against corrosion - decompose at higher temperature - may dissolve in organic solvent

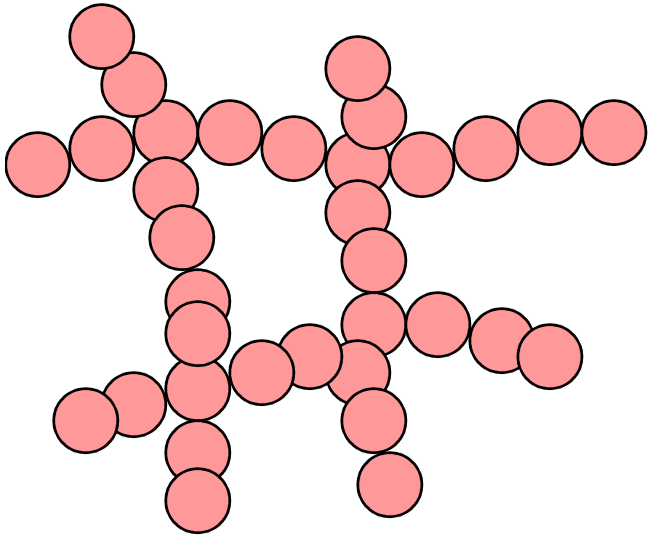
thermal softening and brittleness



non cross-linked polymers:

- soften and melt at high temperatures
- high toughness
- low stiffness (low modulus)

example: polyethylene in garbage containers



cross-linked polymers:

- decompose at high temperatures, do not melt
- high elasticity or high brittleness
- potentially: high stiffness (high modulus)

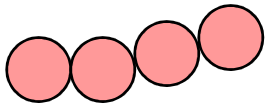
example: epoxy resin for aerospace applications

note: in case of low degrees of polymerization, cross-linked polymers show very elastic, rubber-like mechanical properties.

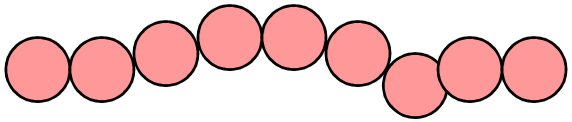
melting point and mechanical strength

melting point and mechanical strength increase with degree of polymerization:

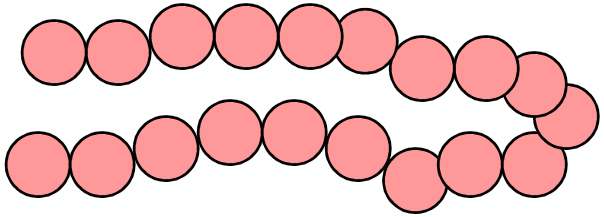
weak



strong

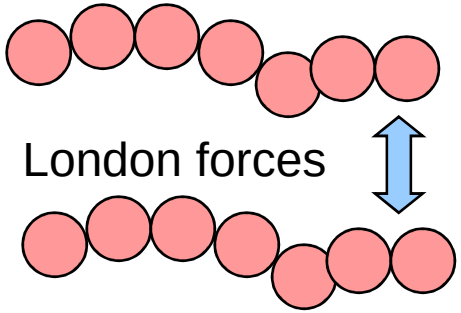


stronger ...



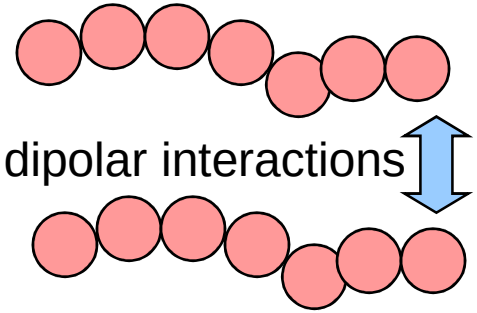
melting point and mechanical strength increase with increasing quality of intermolecular interactions:

weak



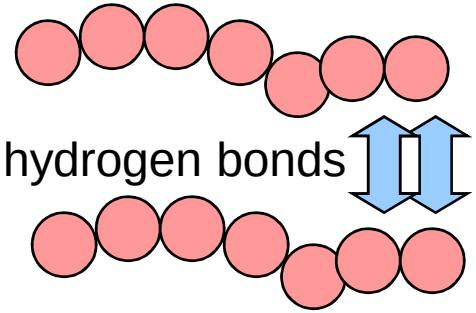
e.g.: Polyethylene

strong



e.g.: Polyester

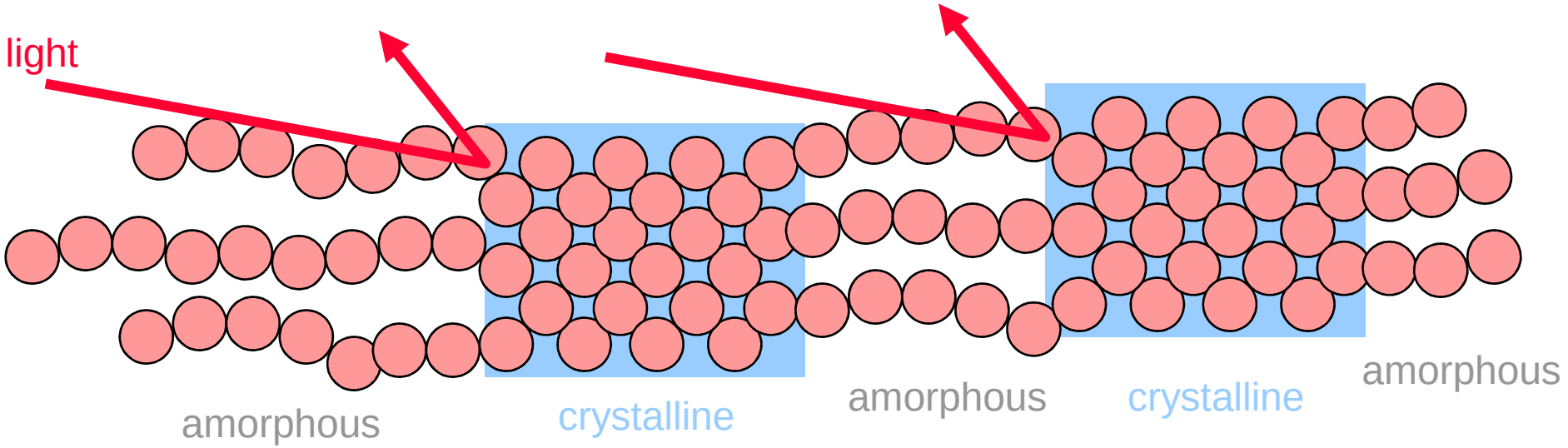
stronger ...



e.g.: Polyamide

transparency

Most polymers tend to form small crystalline structures („crystallites“):



These crystalline portions („crystallites“) tend to scatter light, therefore partially crystalline polymers appear intransparent. Correspondingly, complete transparence can be achieved by avoiding crystallization (e.g. by rapid solidification):