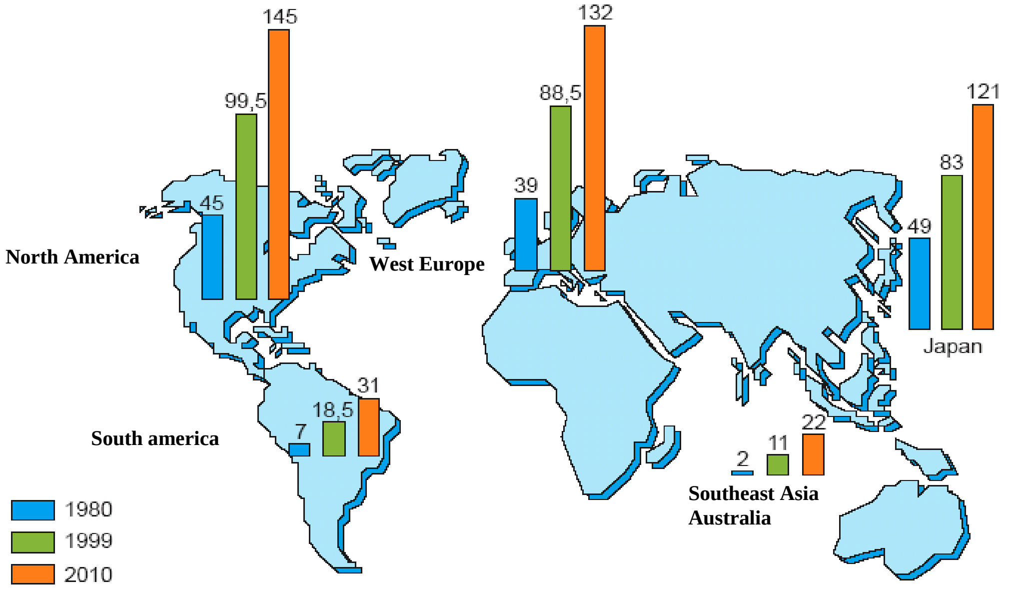
Chapter 1: INTRODUCTION

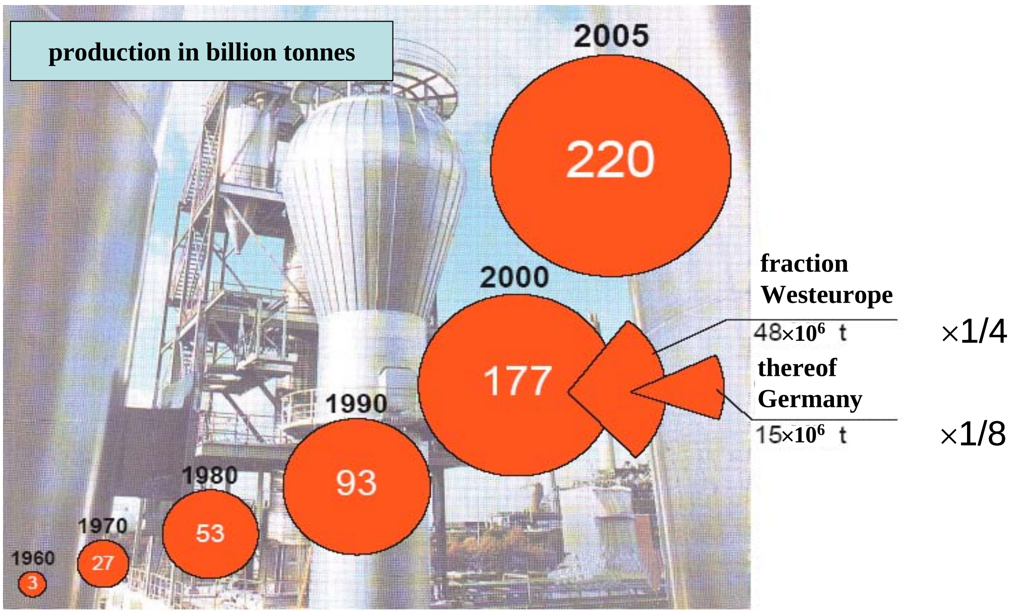
1.1 Plastics in numbers

Plastics [kg] per-capita consumption per year:



Doubling last 20 year, the same trend expected for the next 10 years!

Plastics world market:



Doubling in 10 years!

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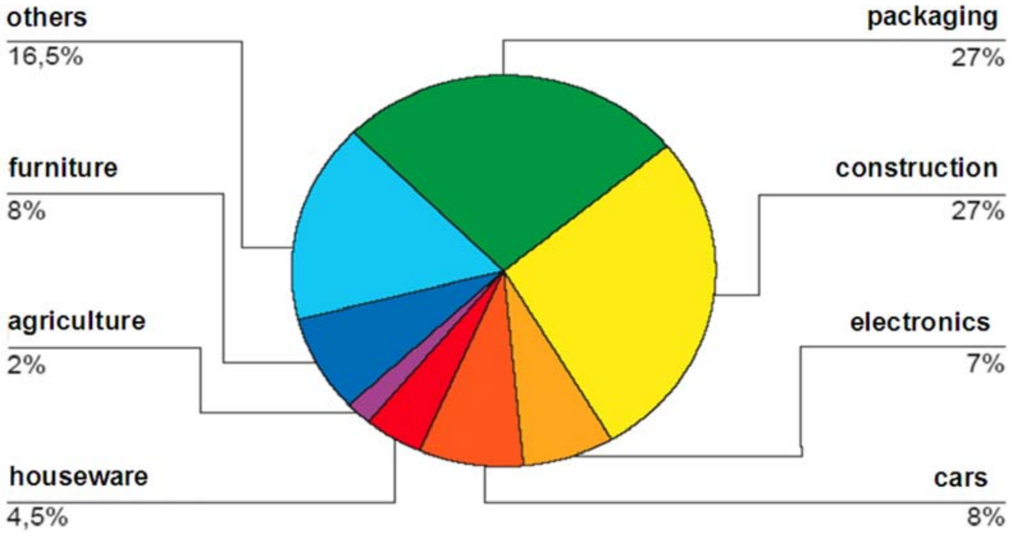
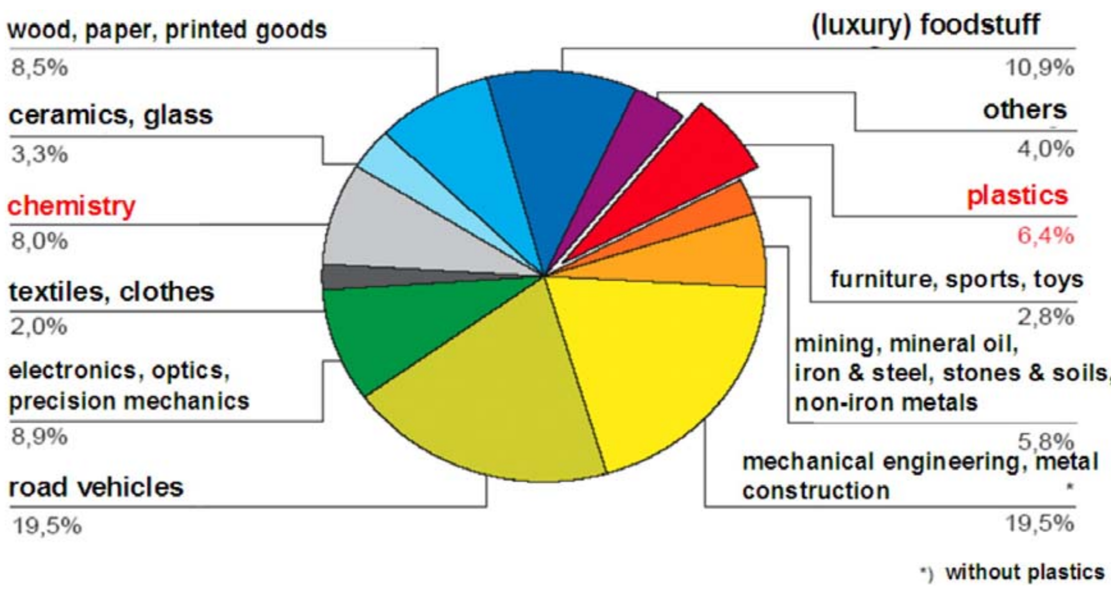
Fields of application (in Germany 2000):



packaging: foils (polystyrene/polypropylene), bags, storage cans (polyethylene).
construction: insulation materials (polyurethanes, styrofoam), binders, adhesives (dispersions), superplastified concrete.
cars: fixtures, steering wheel, dashpot spring, bumper (polycarbonate, polyurethane) tires (synthetic caoutchouc), oil additives.
furniture: binders, adhesives (dispersions).
electronics: insulation materials, casings (blends, block copolymers), organic LED, electrically conducting polymers.
houseware: storage cans (blends).
agriculture: biodegradable foils, hydrogels for water, pesticide, fertilizer storage, encapsulation of ....

Economic relevance of plastics industry in Germany
(as fraction of the value of all industrial, produced goods)



Important monomers for plastics industry

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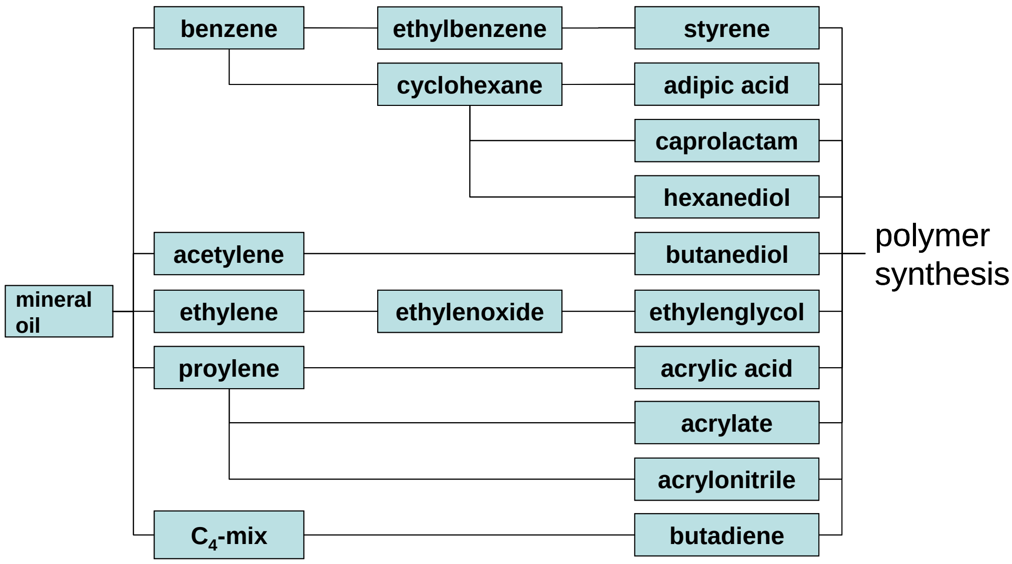


The price increases with number of production steps.

1.2 What is a polymer?

Polymer = Greek *"polumeres"* *"polu" = many* *"meros" = parts*

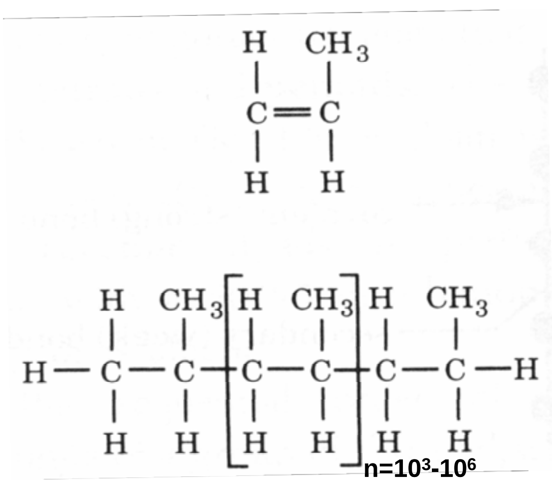
IUPAC definition (Metanomski 1991):
(International Union of Pure and Applied Chemistry)

A polymer is a substance composed of molecules characterized by the multiple repetition of one or more species atoms or groups of atoms (constitutional repeating units) linked to each other in amounts sufficient to provide a set of properties that do not vary markedly with the addition of a few of the constitutional repeating units.

most dominant elements are: C, H, O, N, Cl, F, S, P, Si, ...

Monomer –polymer:

monomer — propylene



polymer — polypropylene

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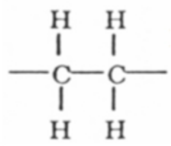
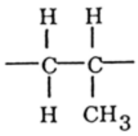
The **backbone** is that part of the chain on the main "path" linking the multitude of monomer units together.
Side groups are chemical groups linked to the backbone in a direction deviant from the main "path" of linking.

Various polymers

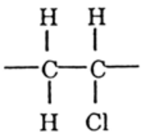
C-C backbone *e.g. polyethylene, PE*



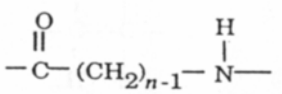
e.g. polypropylene, PP



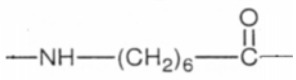
e.g. polyvinylchloride, PVC



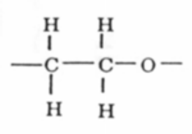
C-N backbone *e.g. polyamide n*



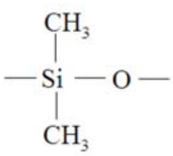
e.g. nylon 6



C-O backbone *e.g. polyethylenoxid*

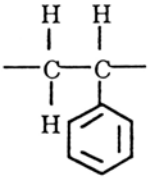


O-Si backbone *e.g. polydimethylsiloxane*



space demanding side chains

polysterene, PS



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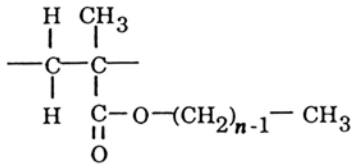
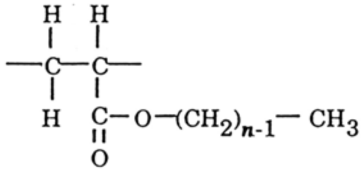
poly(n-alkylmethacrylate)

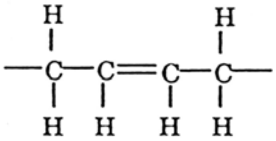


Poly(n-alkylacrylate)

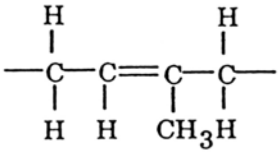


double bonds in backbone

Poly(1,4-butadiene)

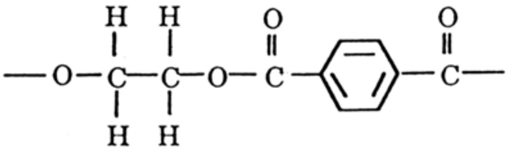


polyisoprene

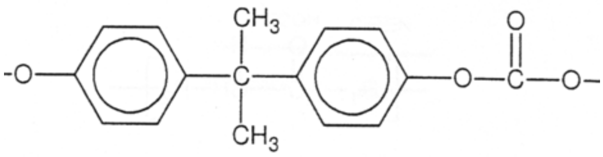


Space demanding groups in backbone

poly(ethylene terephtalate), PETP
with benzene ring



polycarbonate
with phenol ring



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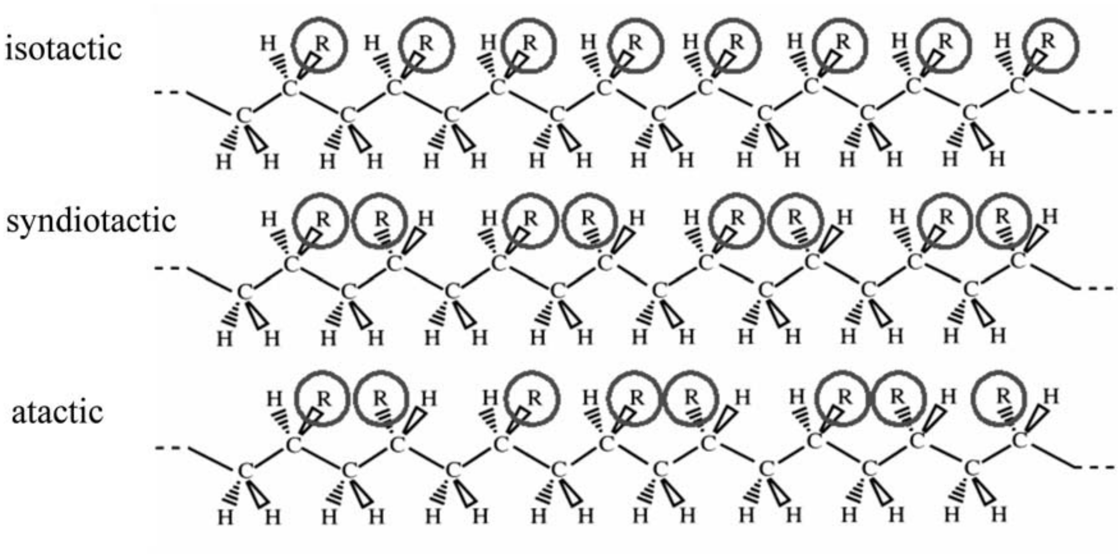
1.3 Architectures: constitution and configuration

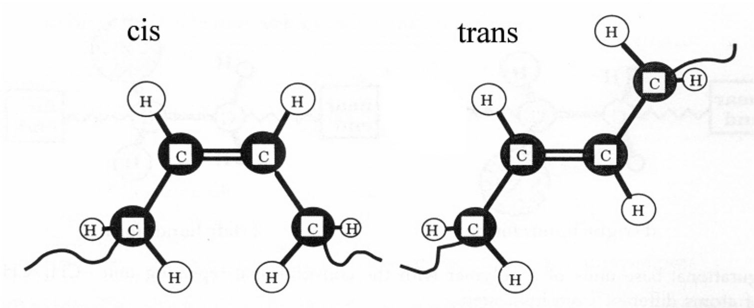
Configuration
refers to the spacial arrangement (orientation) that is determined by the chemical bond. The configuration cannot be altered unless chemical bonds are broken and reformed.
Conformation
refers to the spacial arrangements a chain can attain by rotations around single bonds (see Chap. 3).
Constitution
refers to the type and arrangement of the monomeric building blocks constituting the polymer. (some authors do not distinguish between configuration & constitution)

1.3.1 Configuration
Tacticity



isotactic and syndiotactic: regular arrangement
atactic: irregular arrangements

Cis- and trans-configuration
of a constitutional repeating unit (1,4- polybutadiene) with a rigid central double bond:



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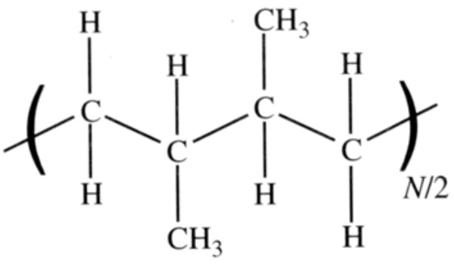
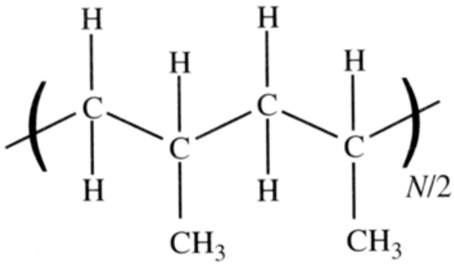
1.3.2 Constitution

Head-to-head and head-to-tail

e.g. polypropylene

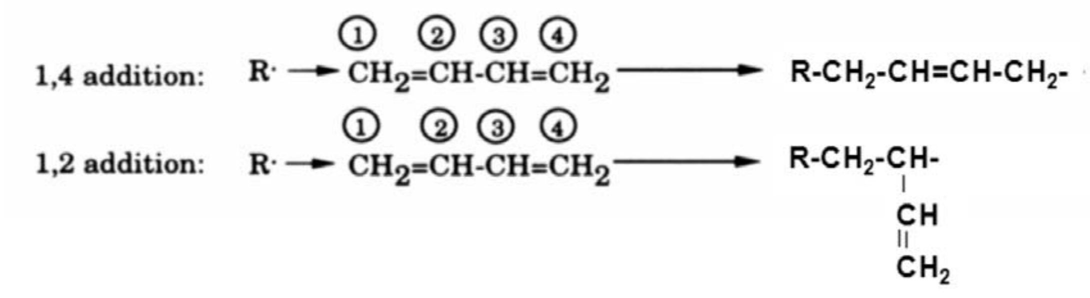


Head-to-head polypropylene

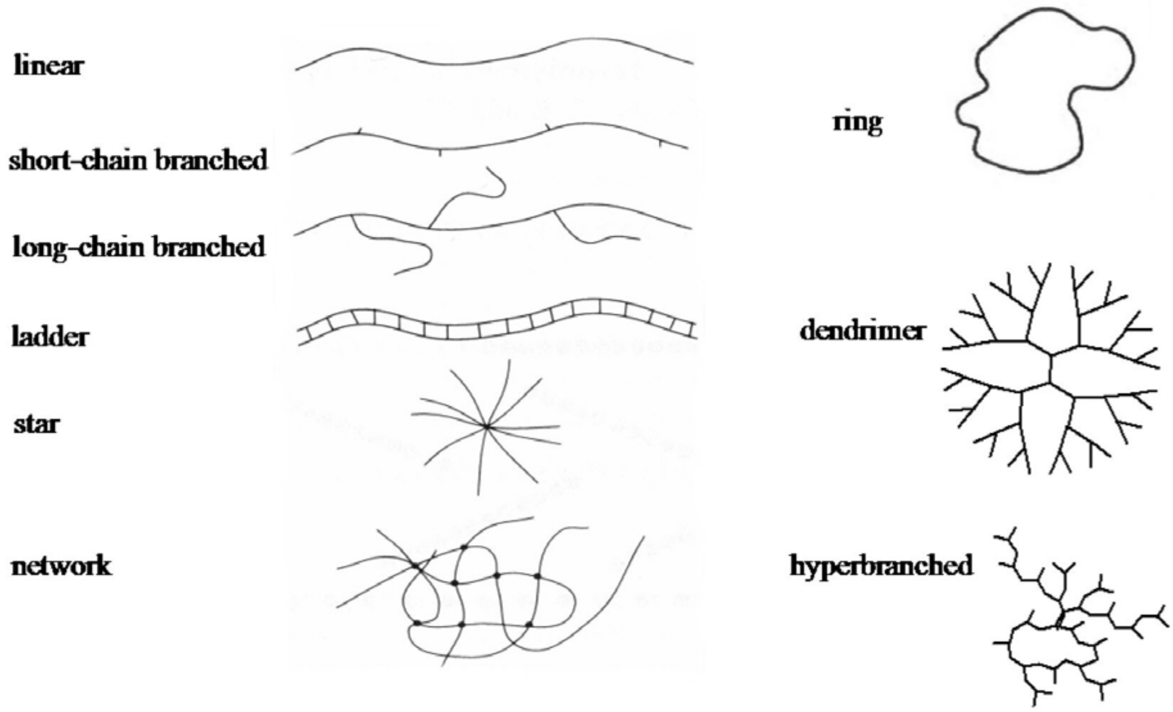


Head-to-tail polypropylene

e.g. polybutadiene



Architectures



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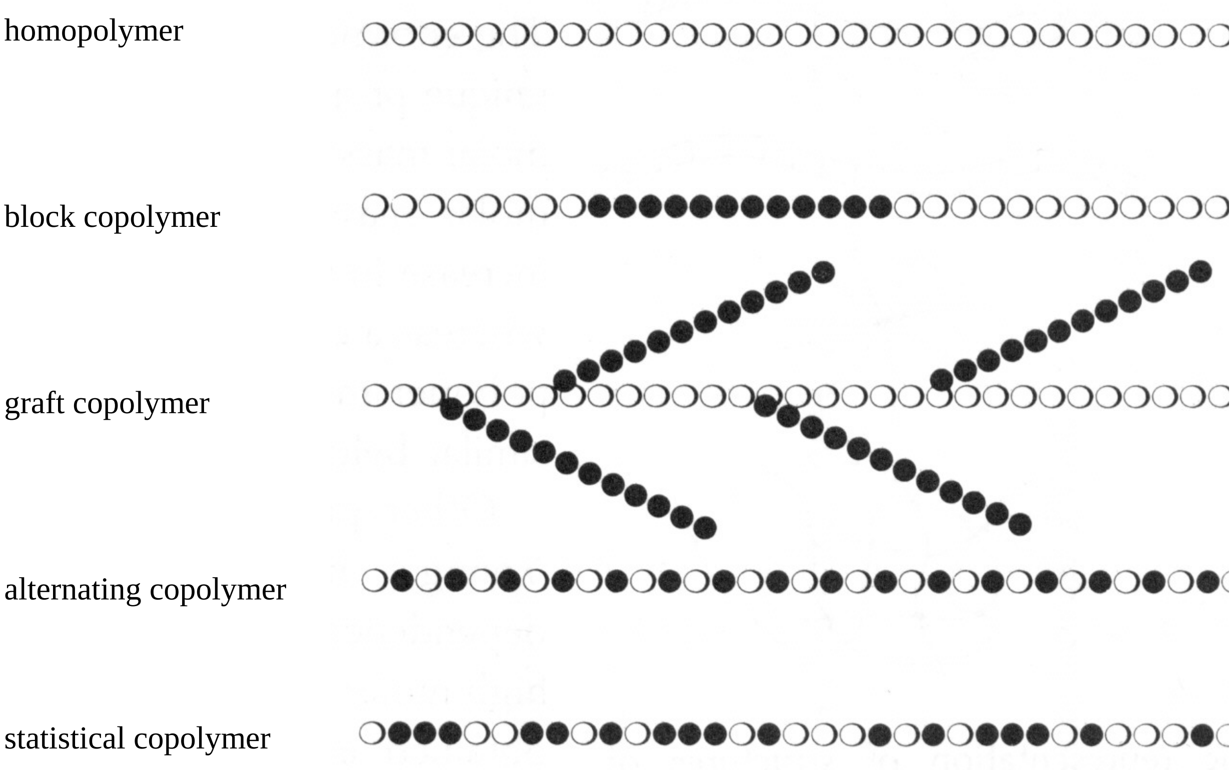
Homo-and co-polymers



Special features of polymers

1. Soft matter covers about 8 decades of length scale from atomic distances, over polymer dimensions up to sample dimensions.
For many properties (on larger length scales) no direct influence of chemical structure or detailes of the solvent; complex mechanical response, dynamic behavior – strongly dependent on length- and time-scale of observation.

2. Connectivity of polymers comprising many building units.
Glass transition (no 1st order phase transition) rather than crystallisation (multidomain); low entropy of mixing - polymers are poorly miscible; large number of conformations in coiled arrangement (high entropy) - polymers shrink with raising temperature due to increased probability to overcome rotational barriers.

3. Different intra-molecular (high binding energies) and inter-molecular (low binding energies) interactions.
Low melting temperature

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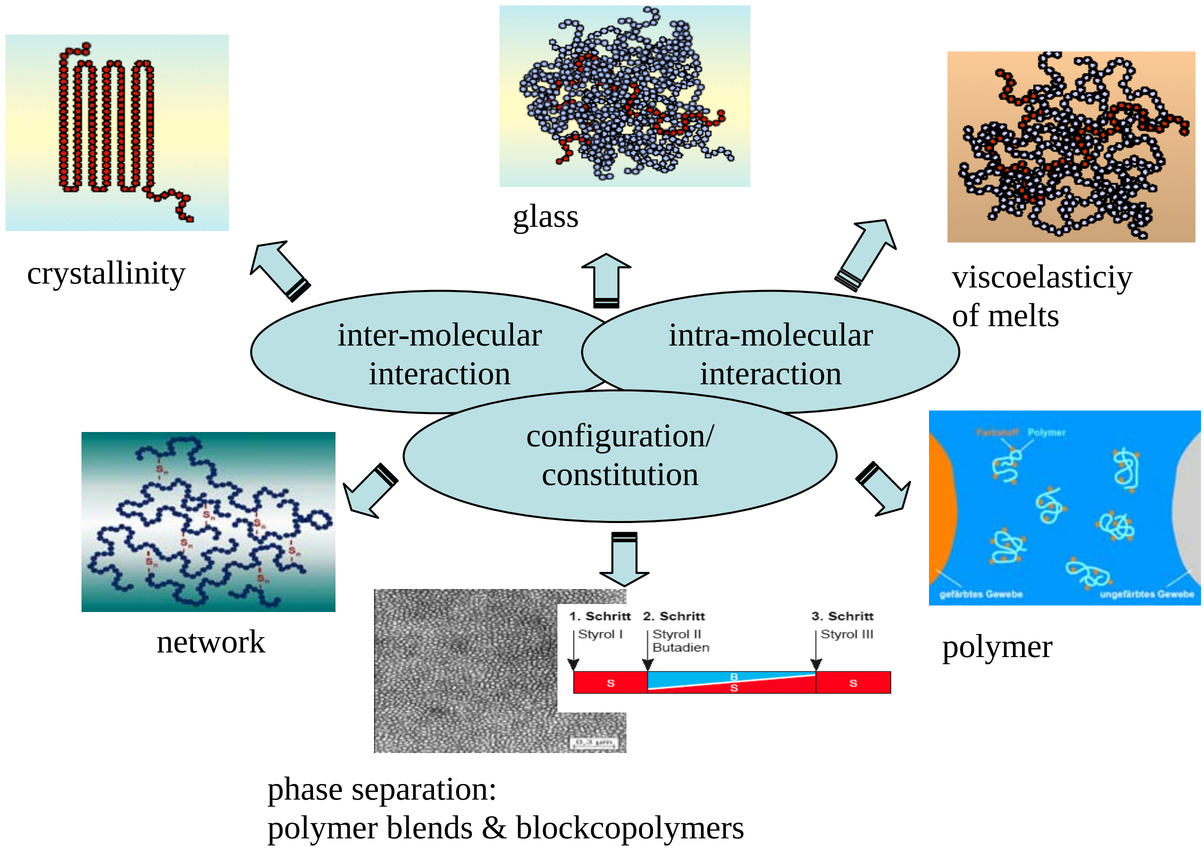

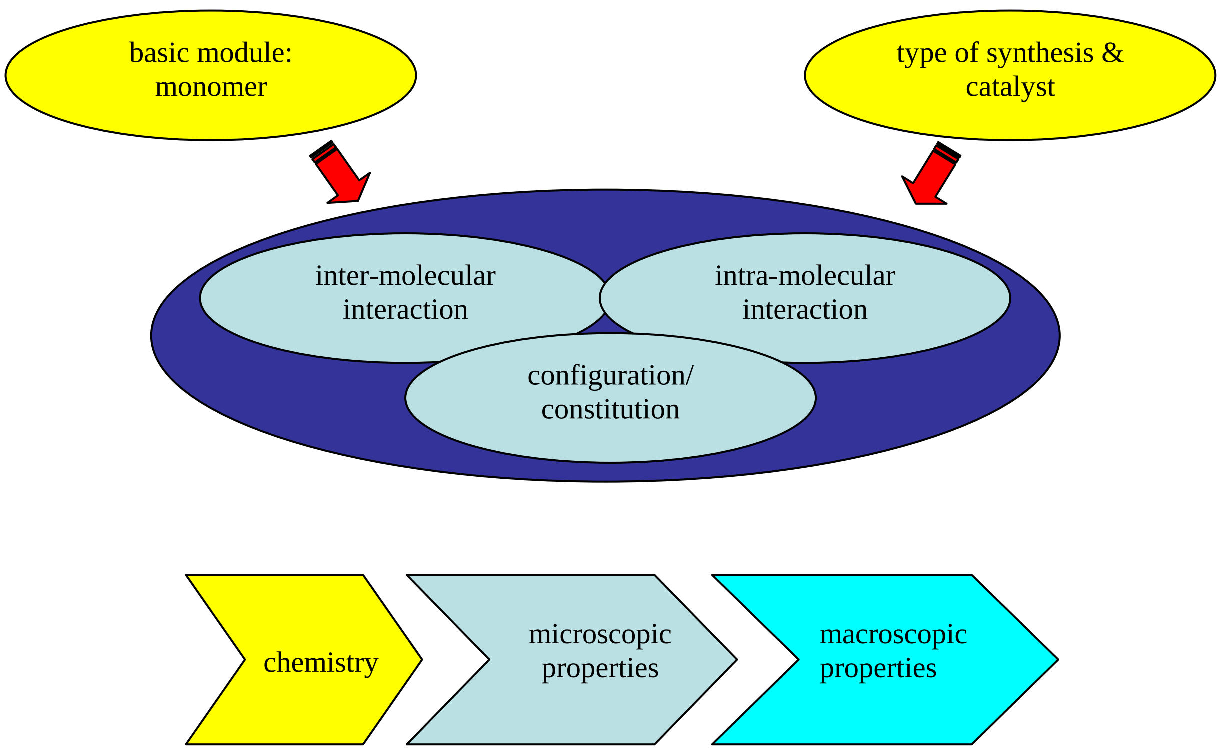

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