



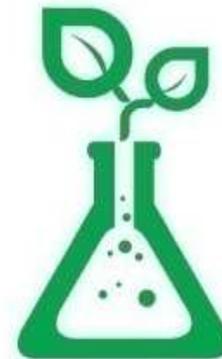
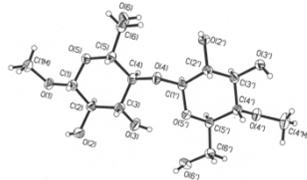
**The chemical basis of  
„bioeconomies“**

# „Chemistry“, „biorefineries“ and „renewables“



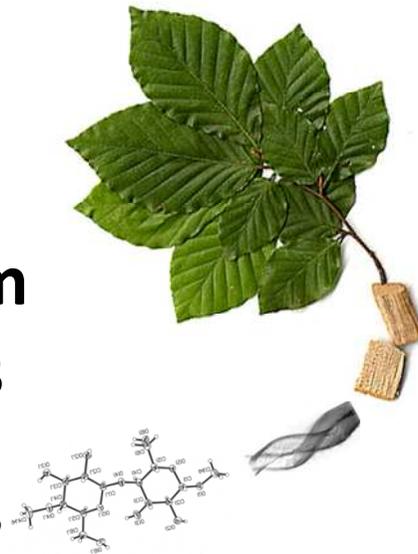
## Green chemistry and biorefineries

Let's look at bioeconomy  
- *through the chemist's eyes*

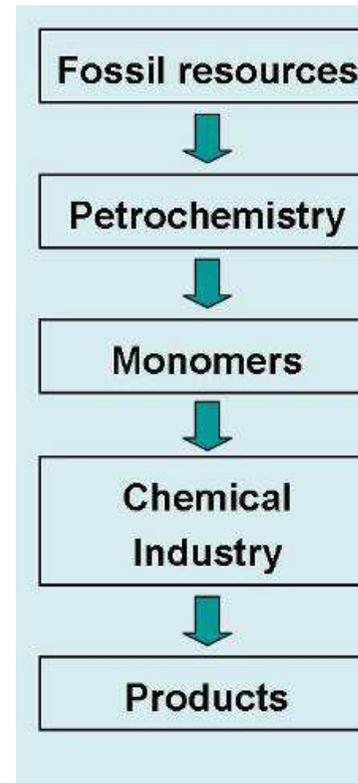


## Products from **bio-refineries**

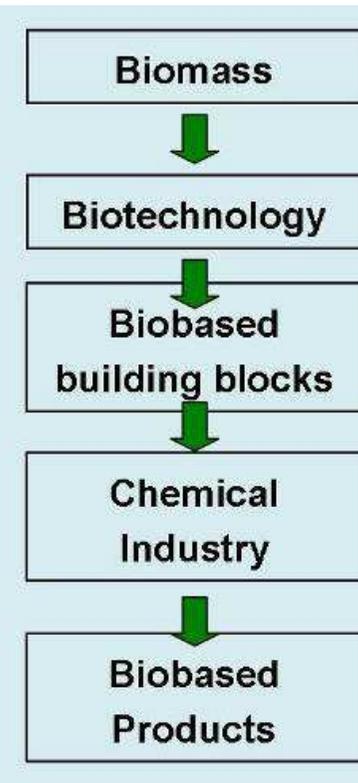
- 1) **Bio-polymers** (Bio-materials)
- 2) **Bio-chemicals**
- 3) **Bio-fuel**
- 4) **Bio-energy**



### Chemistry - Refinery



### Green Chemistry - Biorefinery



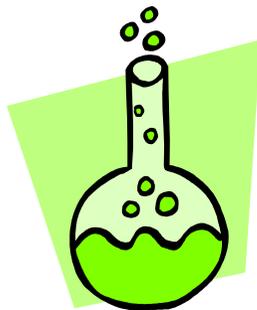
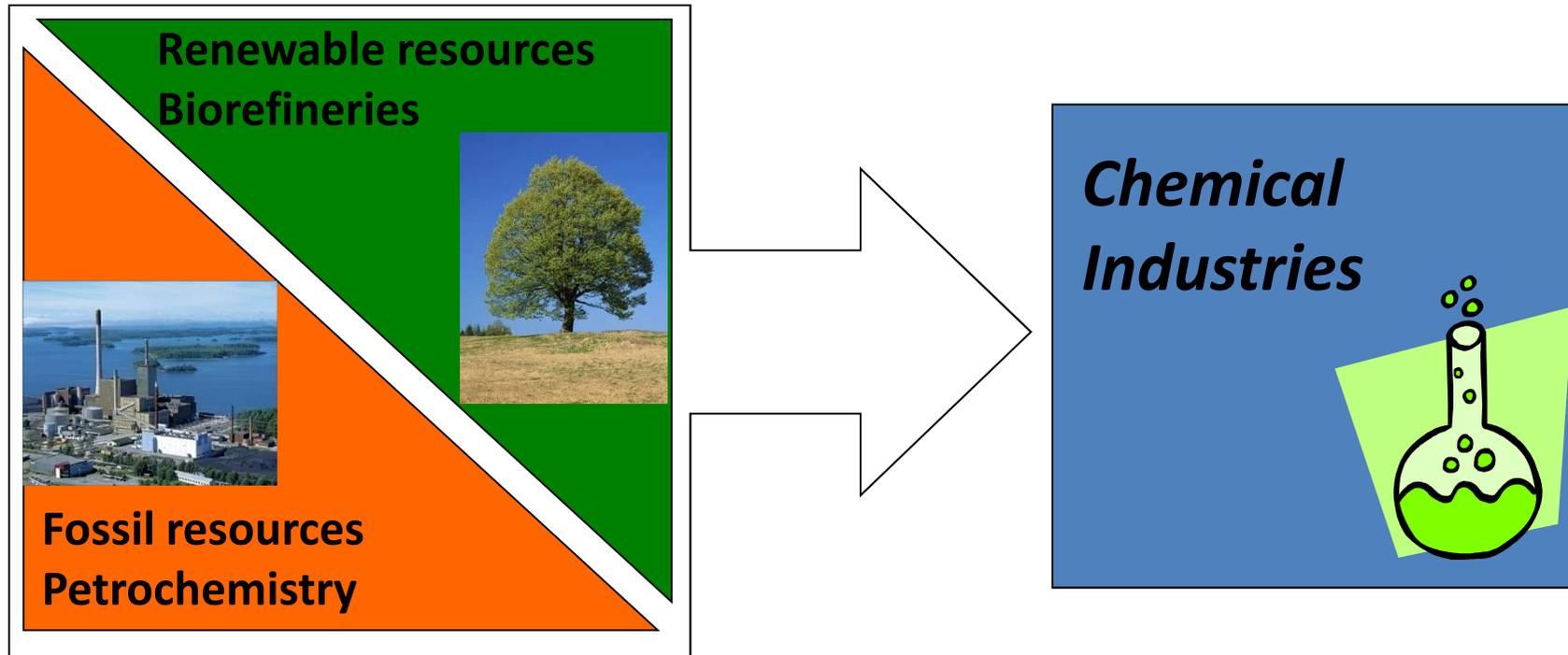
## Definition: **refinery** / **biorefinery**

Fractionation (separation and purification) of **fossil resources** / **biomass** into its main components that are used further to produce an optimum of balanced products



# Looking into the (far) future

The basis of the chemical industries, present and future



In (far) future, fossil resources WILL be used up.

If mankind is not to fall back into a rudimentary, pre-industrial state, the whole production and all flows of the chemical industries will have to be changed from a **petrochemical basis** to a **renewable basis**.

This requires long-term efforts and fundamental research.

Either...

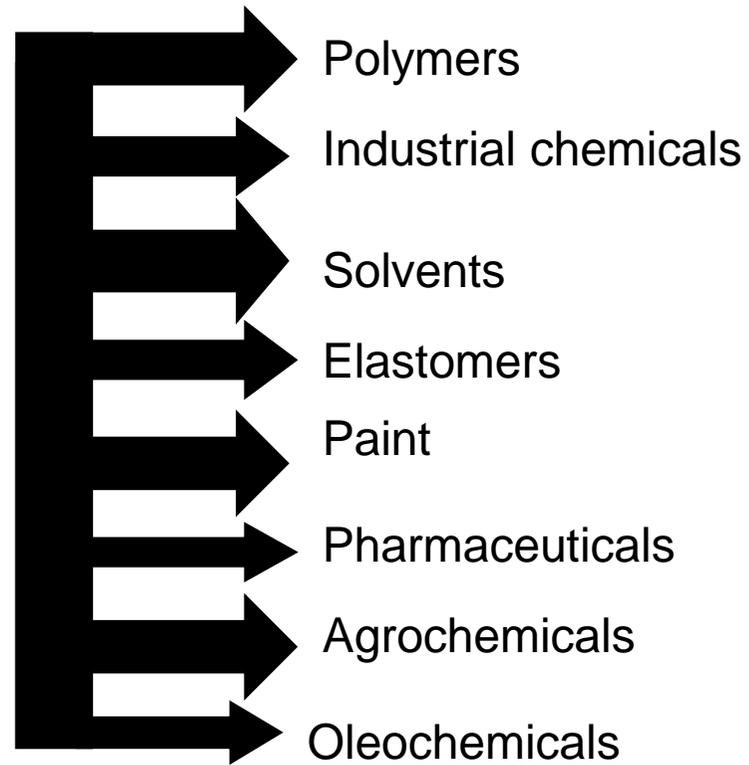


Or...



# Product classes of today's „classical“ chemical industry

- Products from petrochemistry



- Products from industrial biorefineries

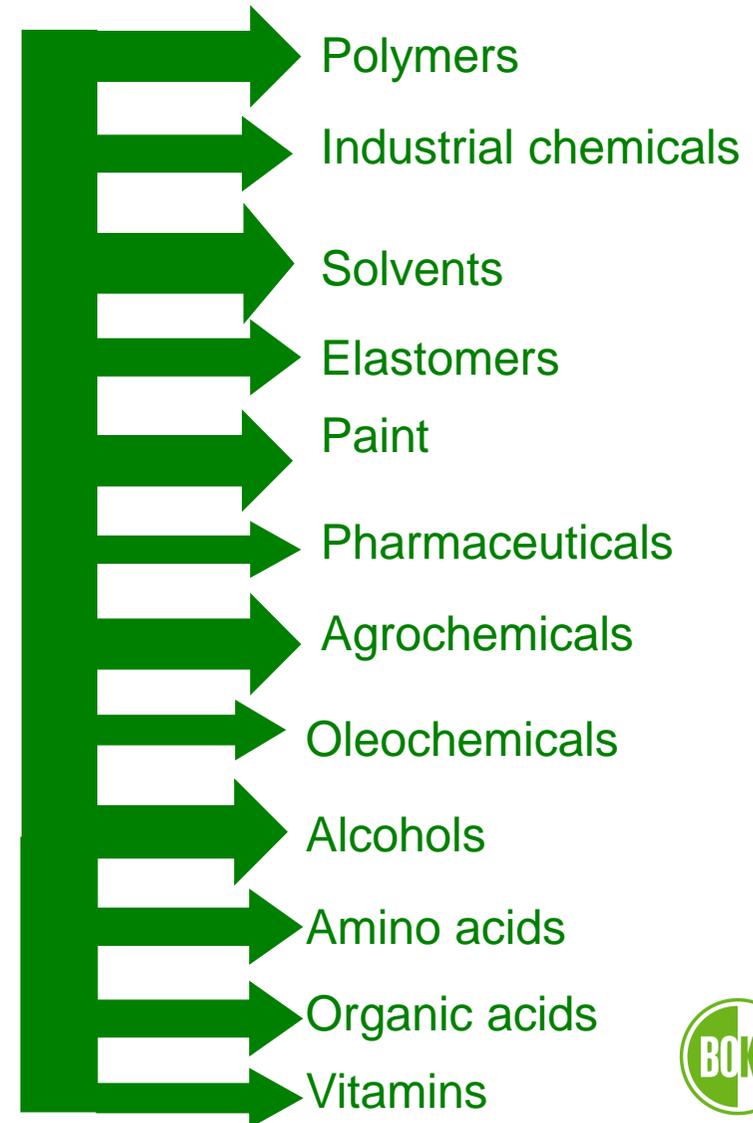


# Product classes of the chemical industry in the far future

**(Bio)chemical technologies producing all materials from renewables, which are nowadays mainly based on fossil resources**

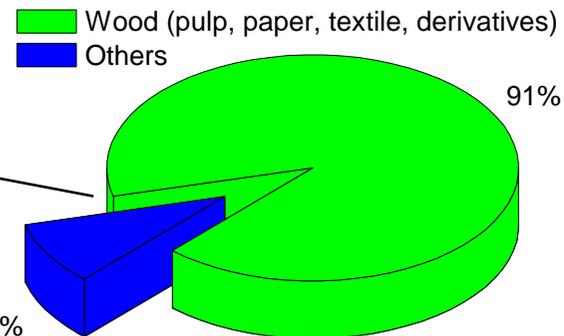
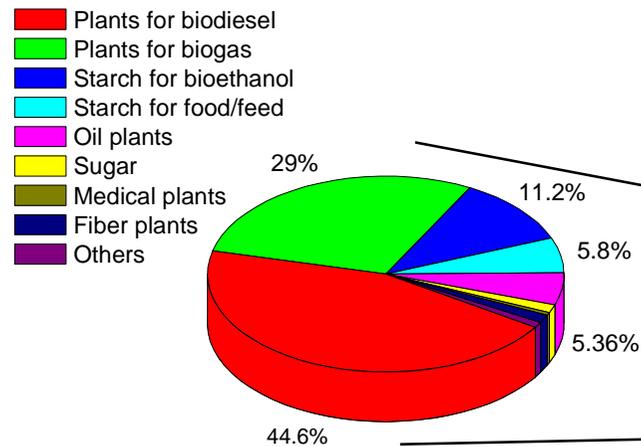
**Change of the basis of chemical industries and all related production lines**

**Fossil → Renewables**

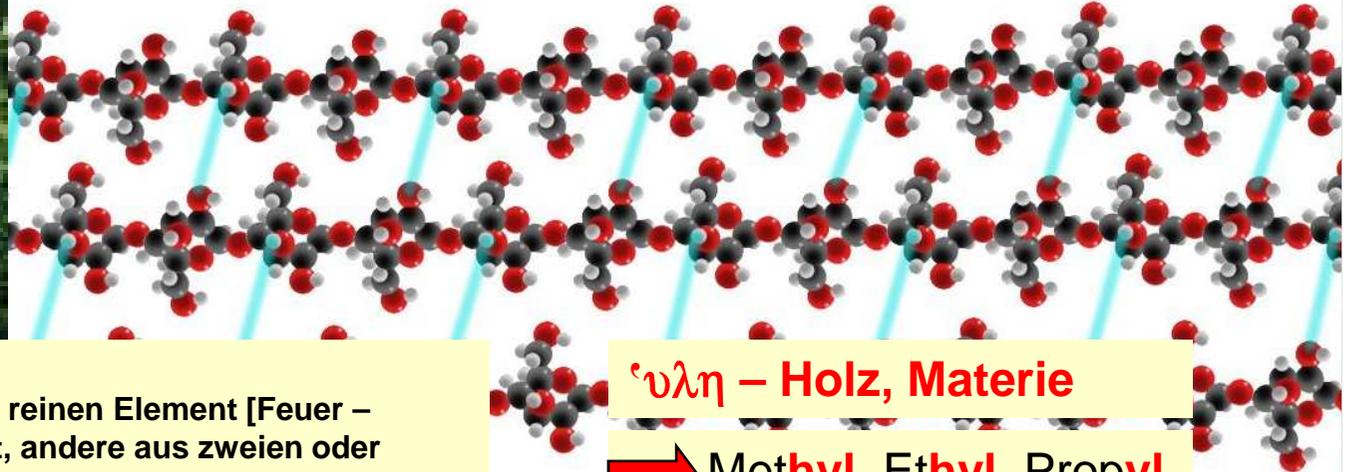
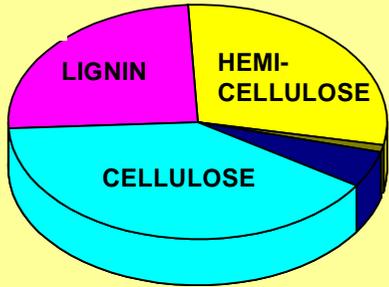


# „Green“ starting materials today

## Mass balance - current situation



In future bioeconomies the whole chemical industry will be based on renewable resources. Today's chemical plants will have transformed into „biorefineries“.

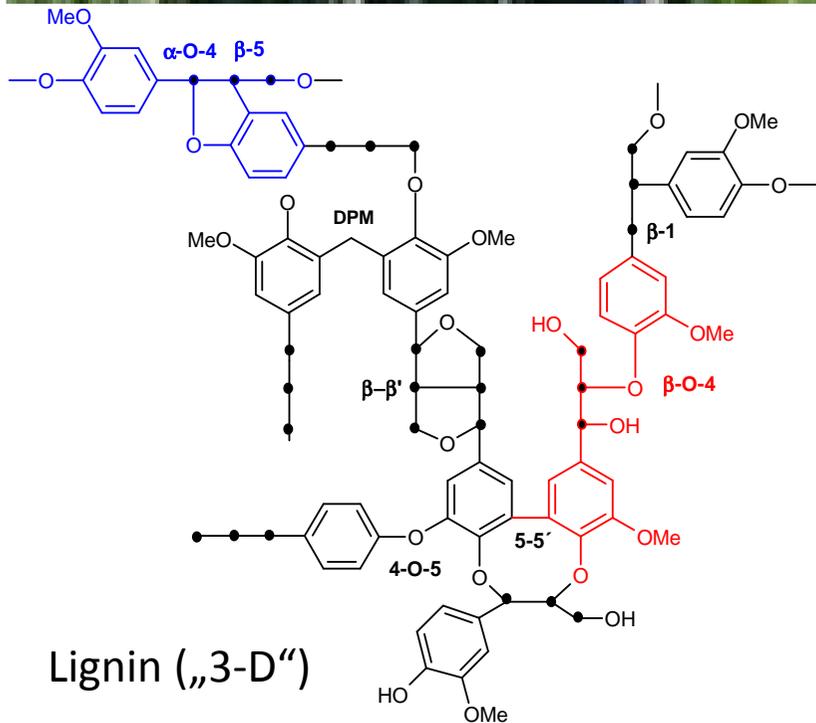


Anaximenes (ca. 550 v. Chr.):

... sind viele Dinge aus einem reinen Element [Feuer – Wasser – Erde – Luft] geformt, andere aus zweien oder dreien, **nur das Holz jedoch bedarf aller vier.**

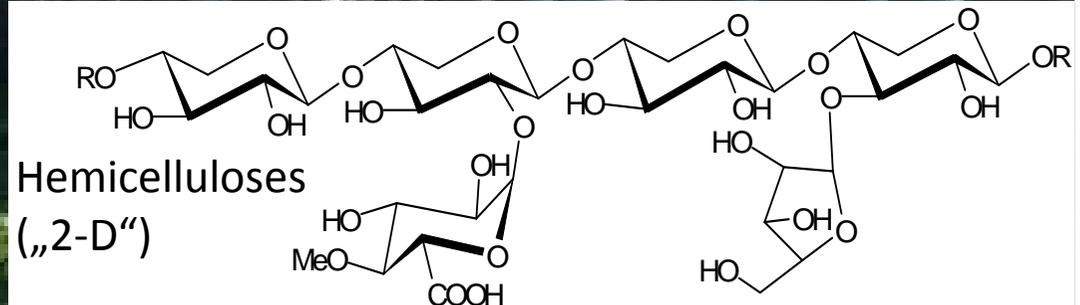
**ἕλη – Holz, Materie**

**→ Methyl, Ethyl, Propyl**



**Other natural starting materials:**

- Extractives (fats, oils, isoprenoids)
- Proteins
- Starch
- Other carbohydrates

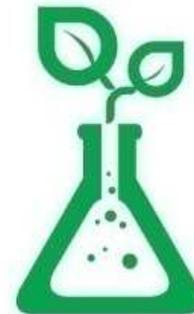
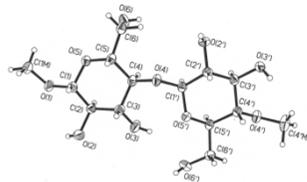


# „Chemistry“ and „renewables“



## Green chemistry and biorefineries

Let's look at bioeconomy  
- *through the chemist's eyes*



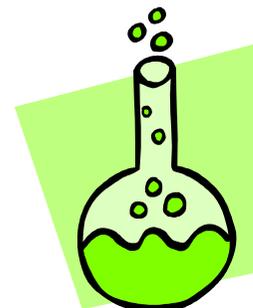
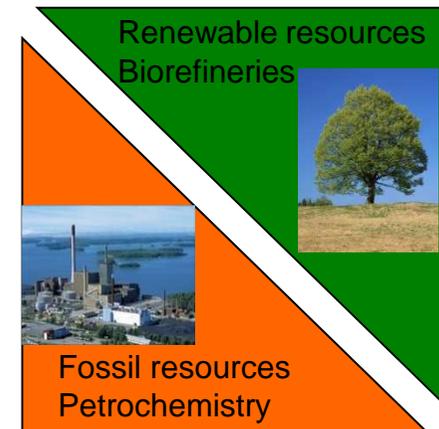


## Energetic vs. chemical utilization

“Use as matter”: chemicals, materials, food, feed

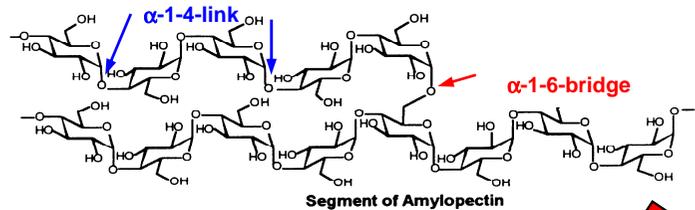


We need “**CARBON**” to produce materials and chemicals.  
We don't necessarily need “**CARBON**” for energy production (there are other and better alternatives) !

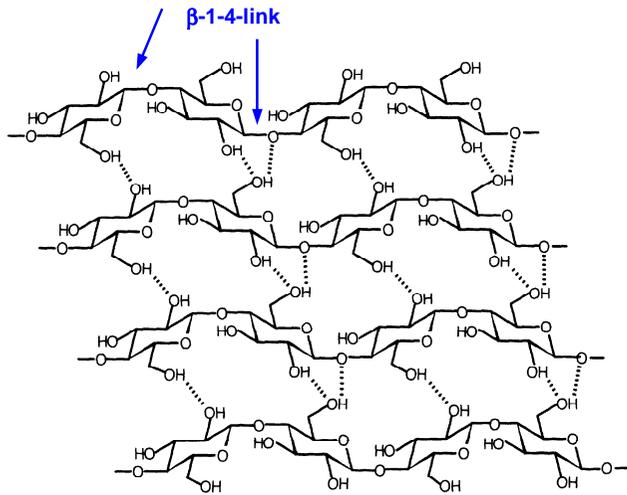




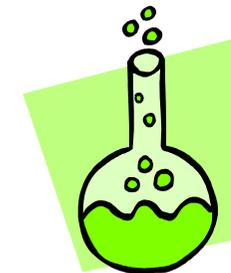
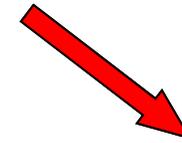
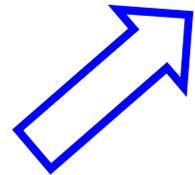
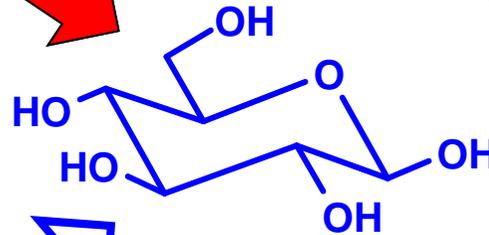
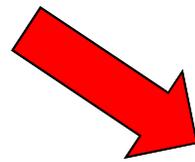
# Food vs. energy / chemicals



**STARCH**



**(Hemi)CELLULOSES**

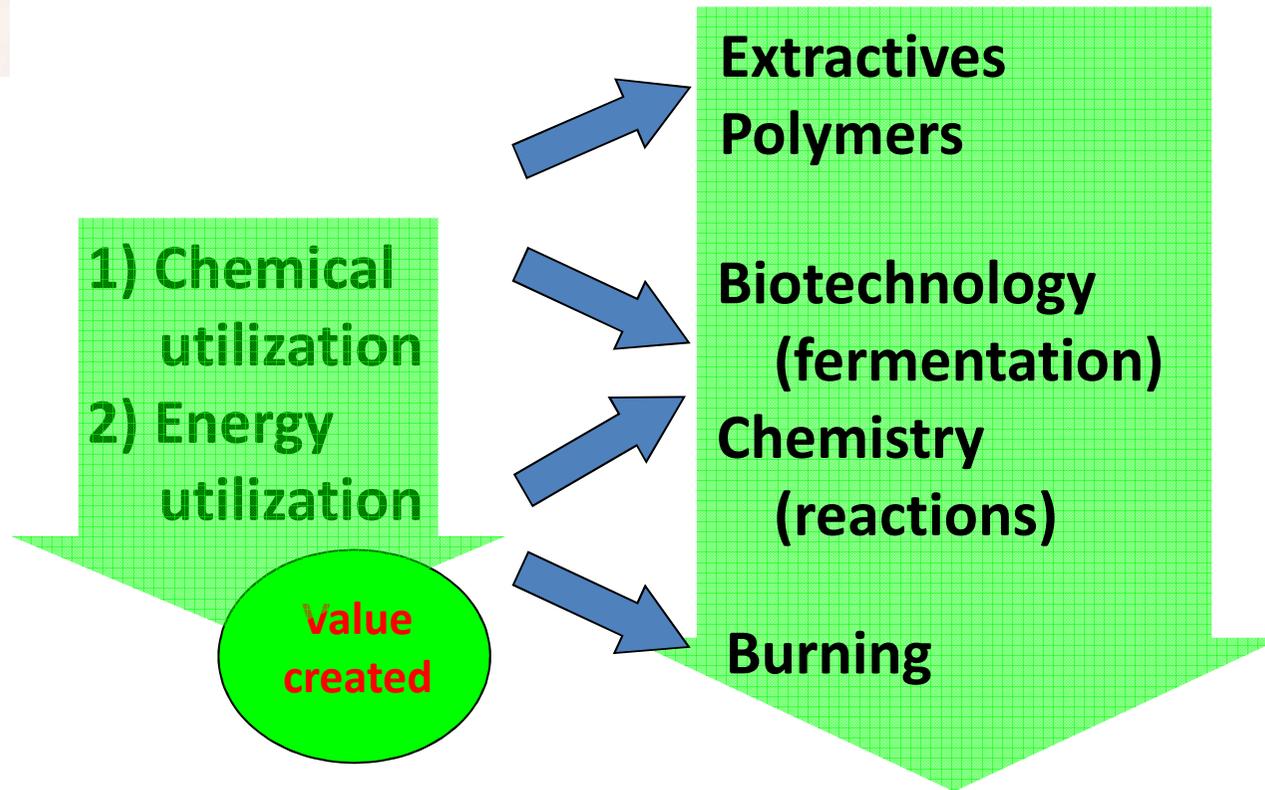


→ On the long run, energy and chemicals / materials will be derived from natural resources that have no competitive utilization in the food / feed market.

→ This requires long-term research efforts (and might require improved ethical thinking as well).



## Cascade utilization



→ “Do something with it first! If nothing works – you can still burn it!”  
(George A. Olah, Nobel Prize Chemistry 1994)

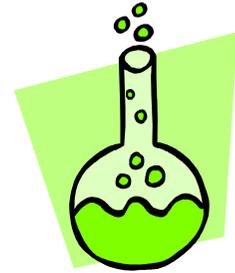
→ Energy usage modes (biogas, pyrolysis oils, direct burning) should be operated only after value-added chemical utilization.

→ A major hindrance in cascade utilization is the insufficient advancement of separation technology and analytical capability today.



# “Drop-in strategy” vs. “use-as-is strategy”

Acknowledging nature’s synthesis efforts



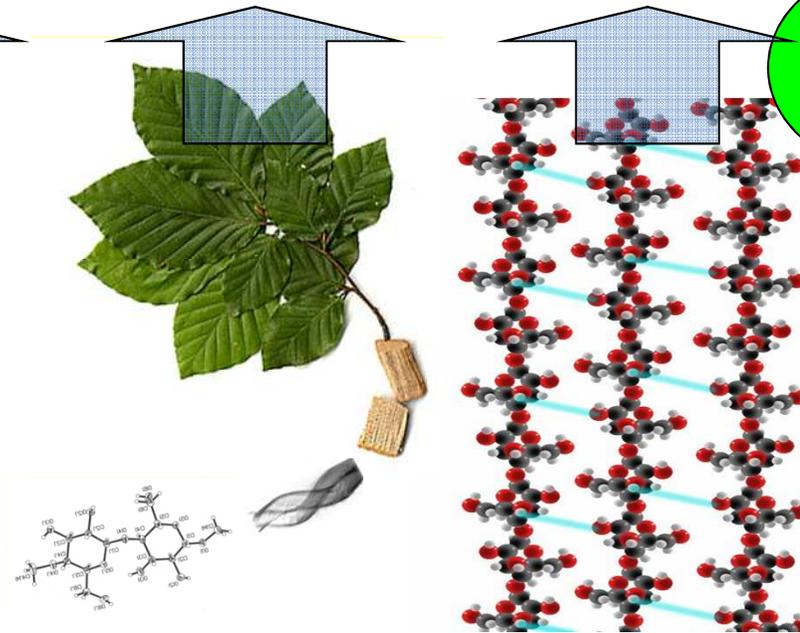
## (Bio) Refinery

## Chemical industries



**Future renewable chemistry („biorefineries“):**

**Providing necessary chemicals (what the fossil fuels do today) PLUS**  
**Biogas by cascade utilization PLUS**  
**Providing special and novel materials by better use of the intrinsic properties**



**Value created**

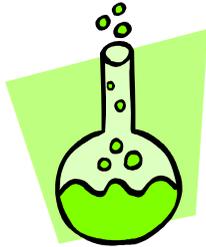
- If possible: preserving the unique properties of the raw material – not just destroying it!
- Acknowledge and utilize the synthesis and optimization effort of nature !



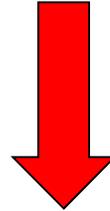


# How green ~~can~~ must & will chemistry get ?

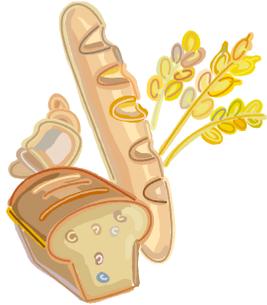
In evitable general future developments



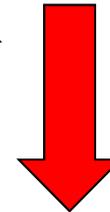
Material / chemical utilization



Energetic utilization



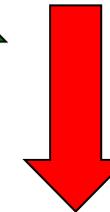
Food / feed if possible



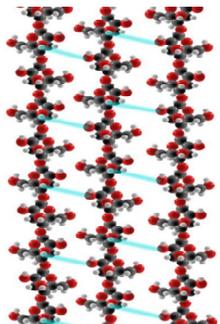
Energy / chemicals from food-/feedstock



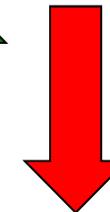
Cascade utilization



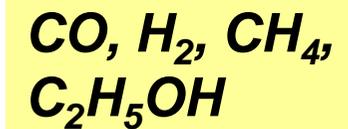
Direct (one-step) utilization



Better use of nature's ingenuity in synthesis and material production



Extensive breakdown of renewables „green-to-oil“





**Thanks to the people who  
are actually doing the work...**





[thomas.rosenau@boku.ac.at](mailto:thomas.rosenau@boku.ac.at)

