Let‘s make it work! Specialty chemicals from syngas

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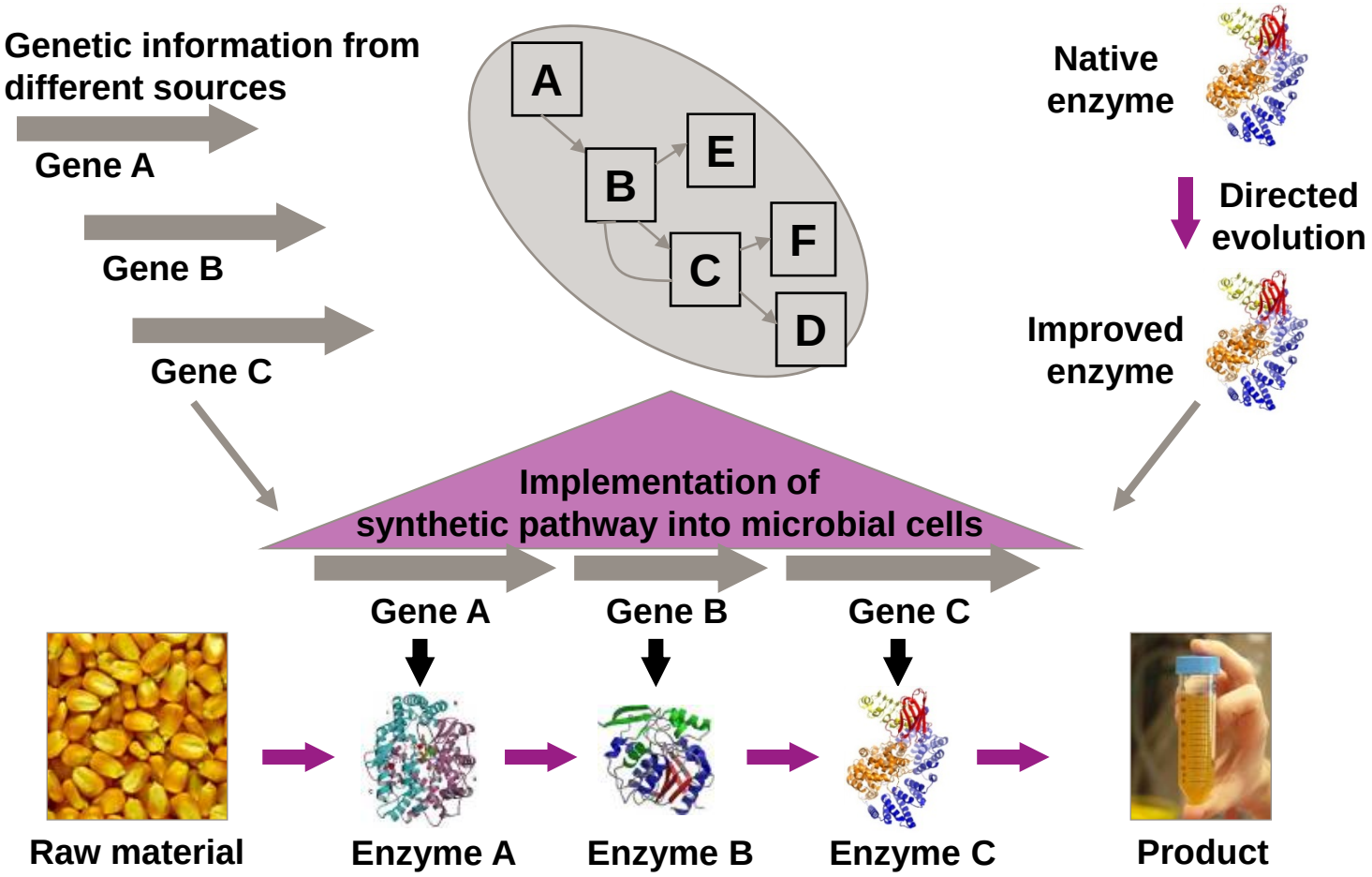
EVONIK INDUSTRIES

„Factories in a cell“ provide a new access to specialty chemicals



Syngas fermentation is 3rd generation biotechnology

Generation	Raw material	Biotechnology
1st gen	Plant oils Wheat Corn Sugar	Direct fermentation
2nd gen	Biomass residues from agriculture and forestry	Lignocellulose hydrolysis Integrated fermentation
3rd gen	Municipal waste Plant residues Industrial waste gases	Syngas fermentation

Syngas (CO,CO_2,H_2) is broadly and easily accessible

Waste streams of coke oven or steel mills, e.g. converter gas:

CO, CO_2, H_2 in NRW > 2 mil. to/a

Steam reforming or catalytic oxidation of **CH_4 (Natural Gas)**:

$CH_4 + H_2O \rightarrow CO + 3H_2$ $2CH_4 + O_2 \rightarrow 2CO + 4H_2$

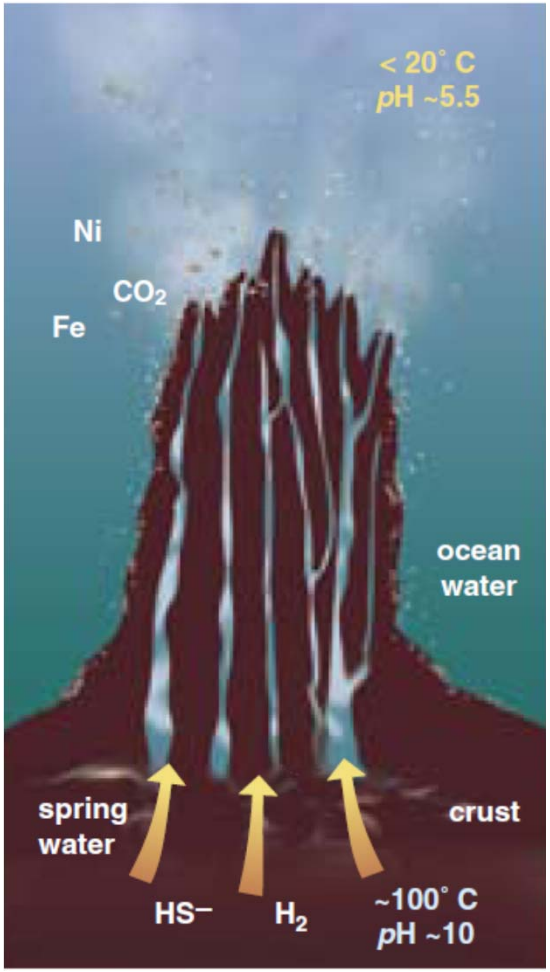
Biomass gasification:

$C_6H_{12}O_6 \rightarrow 6CO + 6H_2$

Mixing of **CO_2 waste streams** (e.g. power plant off-gas) with exogenic H_2 (e.g. from solar energy)

Syngas cell factories use nature‘s toolbox from early days of life

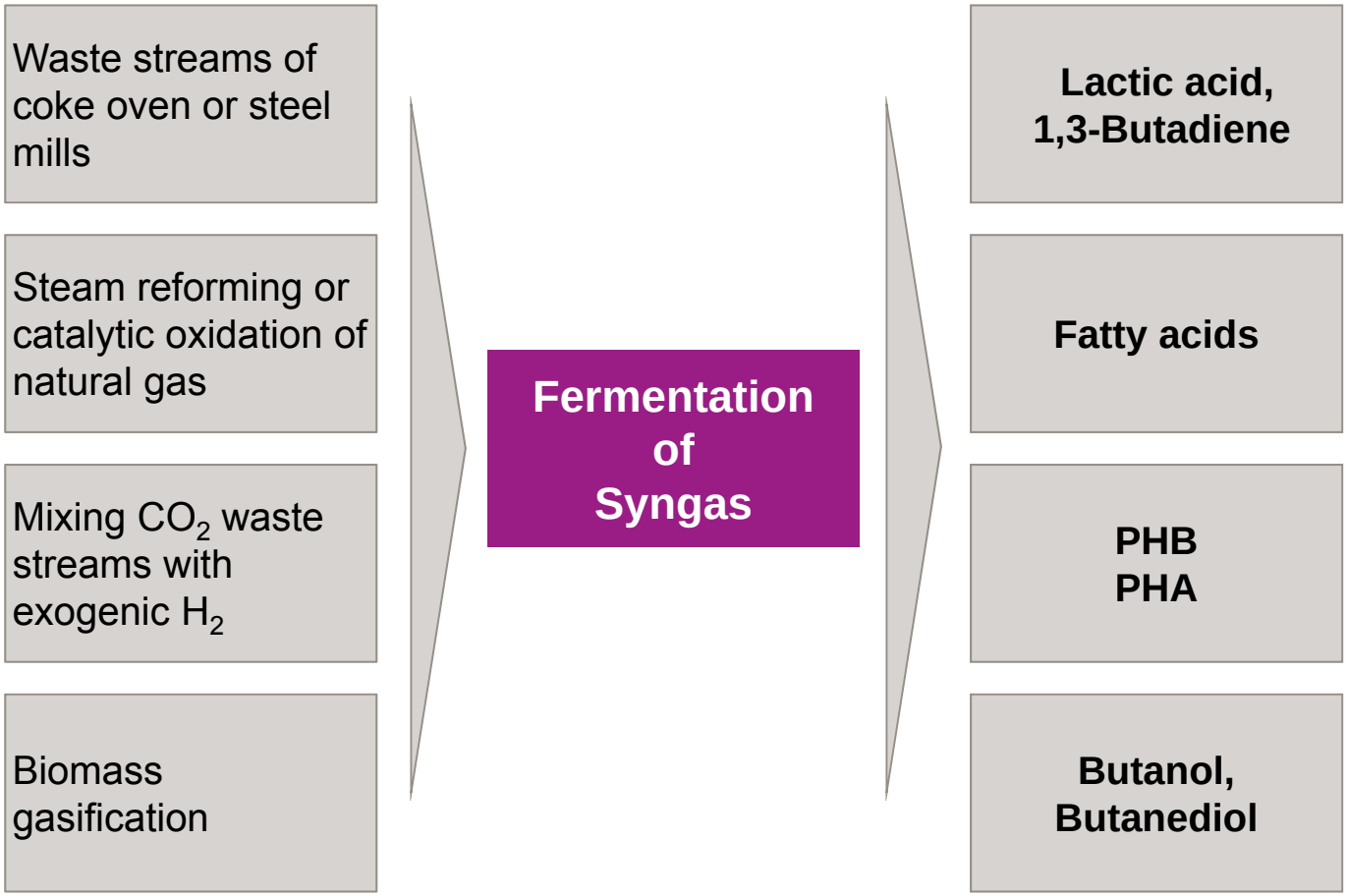
- 3.5 billion years ago the earth was rich in H_2 and CO_2 and covered with water
- Primitive proto-methanogens and -acetogens evolved into bacteria and archaea
- These chemolithotrophic organisms, acetogens and methanogens, are capable of using H_2 and CO_2 for energy generation and growth



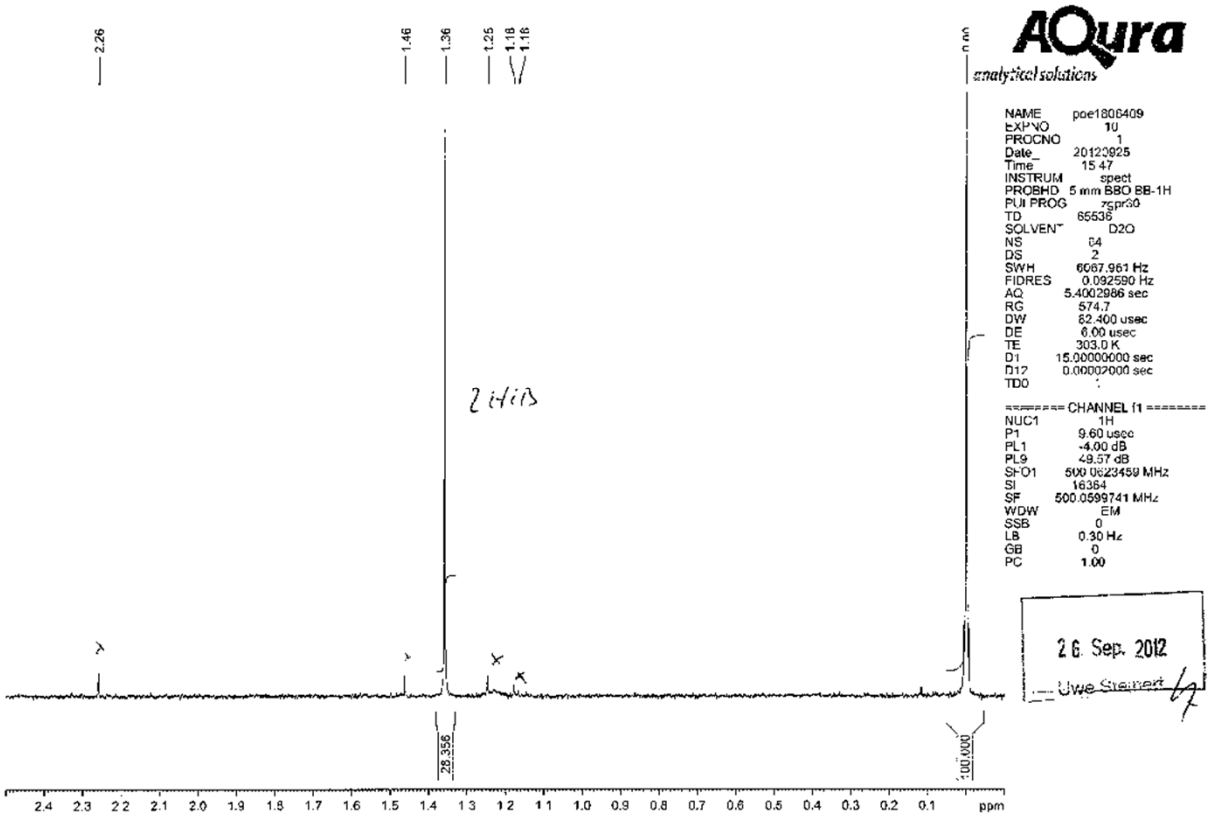
M. Russel (2006) First Life. American Scientist, 94, 32-39

W. Martin (2009) Alles hat einen Anfang, auch die Evolution: Hydrothermalquellen und der Ursprung des Lebens. Biol. Unserer Zeit, 39 (3), 166-174

Syngas fermentation provides high raw material flexibility

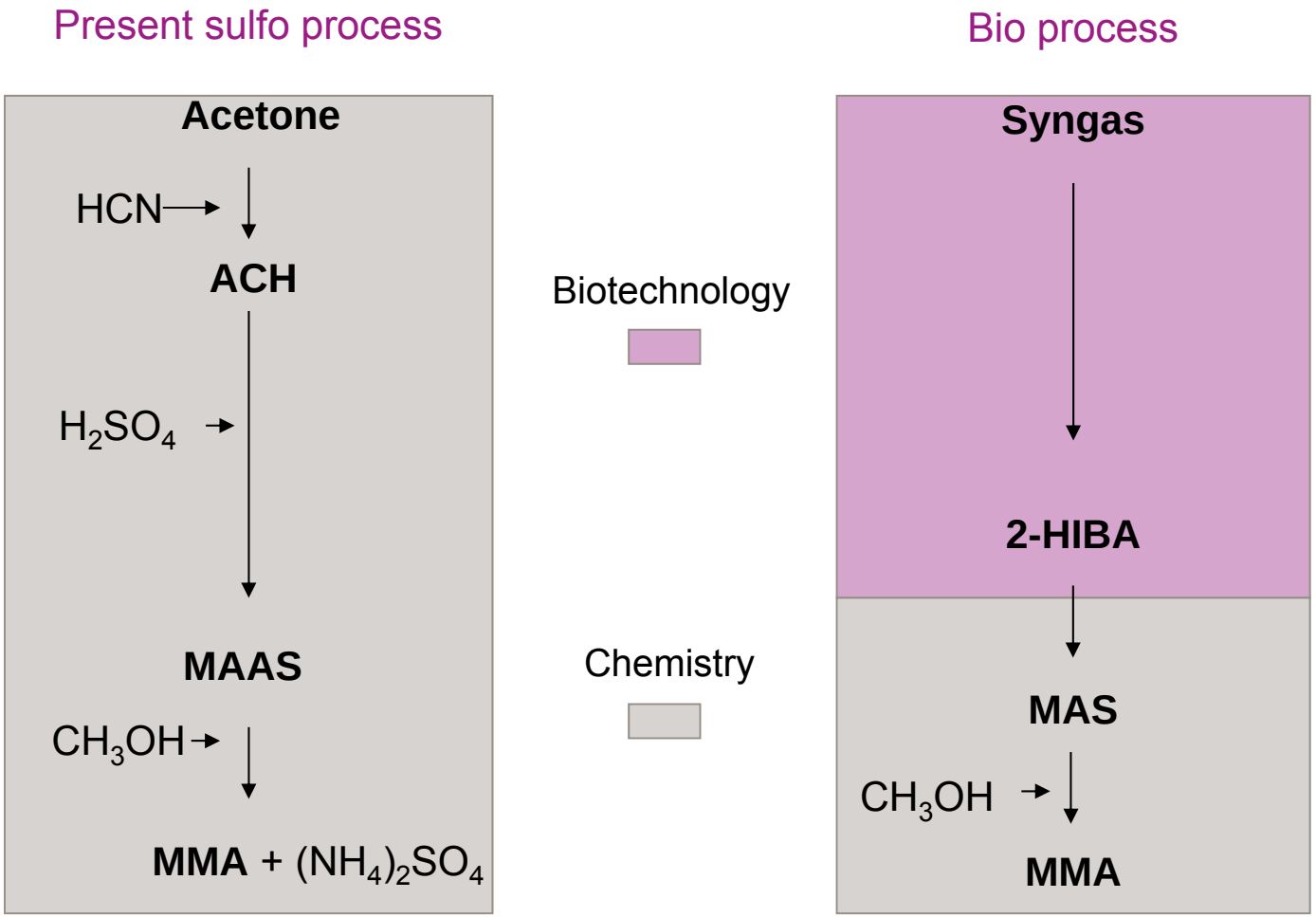


The first specialty chemical from syngas fermentation: 2-HIBA

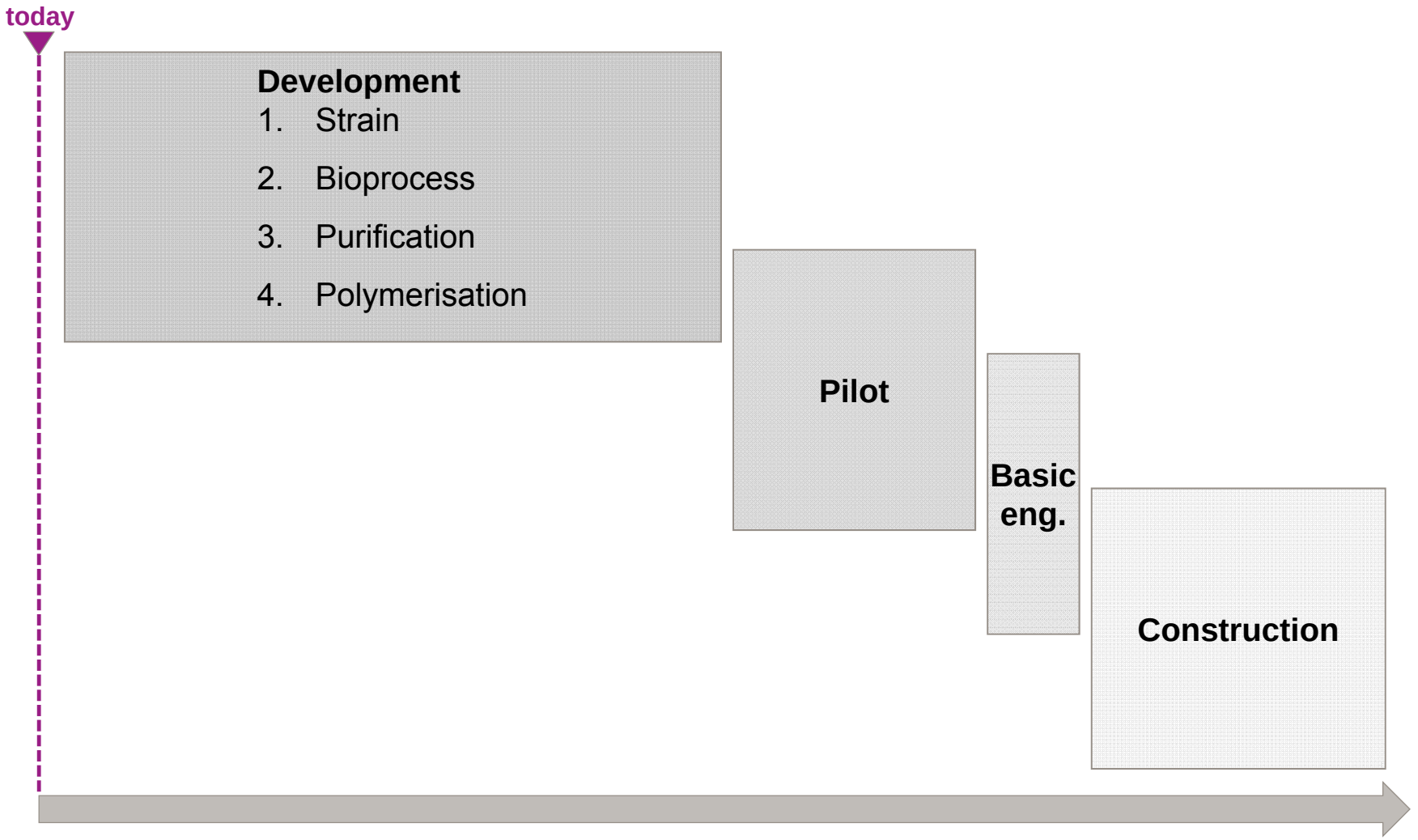


Genetically modified organism is able to produce highly selective 2-HIBA under autotrophic conditions with syngas.

Syngas based biotech process for acrylic glass



Syngas fermentation: Time to market



Summary

- “Factories in a cell” provide a new access to speciality chemicals like performance monomers, fatty acids, surfactants etc., using alternative raw materials.
- Cell factories fermenting syngas unchain the production of speciality chemicals from specific raw materials. They provide a maximum raw material flexibility.
- Syngas fermentation represents a new approach to invest close to the customers with a very competitive cost position.

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