



UNIVERSITY OF
BIRMINGHAM

ETH zürich

DEVELOPING A SYSTEMS THINKING-BASED CURRICULUM FOR CATALYSIS EDUCATION

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Contributed talk
VICEPHEC21

REDUCTIONISM & SYSTEMS THINKING

How does a car work?

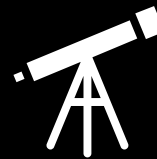


Breakdown into individual parts



Think as a whole

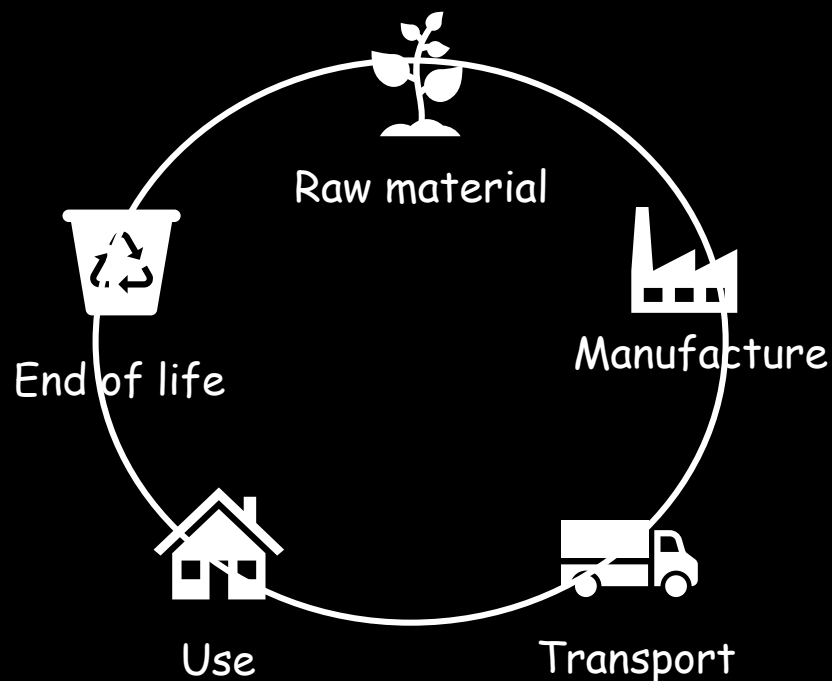
Reductionism & systems thinking are complementary, not conflicting thinking approaches



REDUCTIONISM AND CHEMISTRY

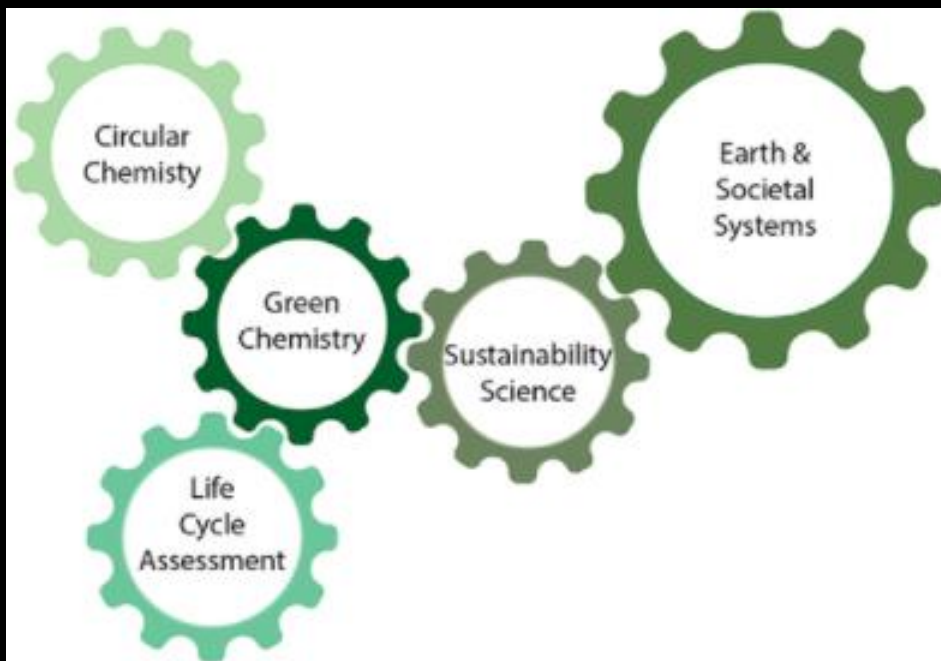
Branches of chemistry

- Analytical
- Inorganic
- Organic
- Physical

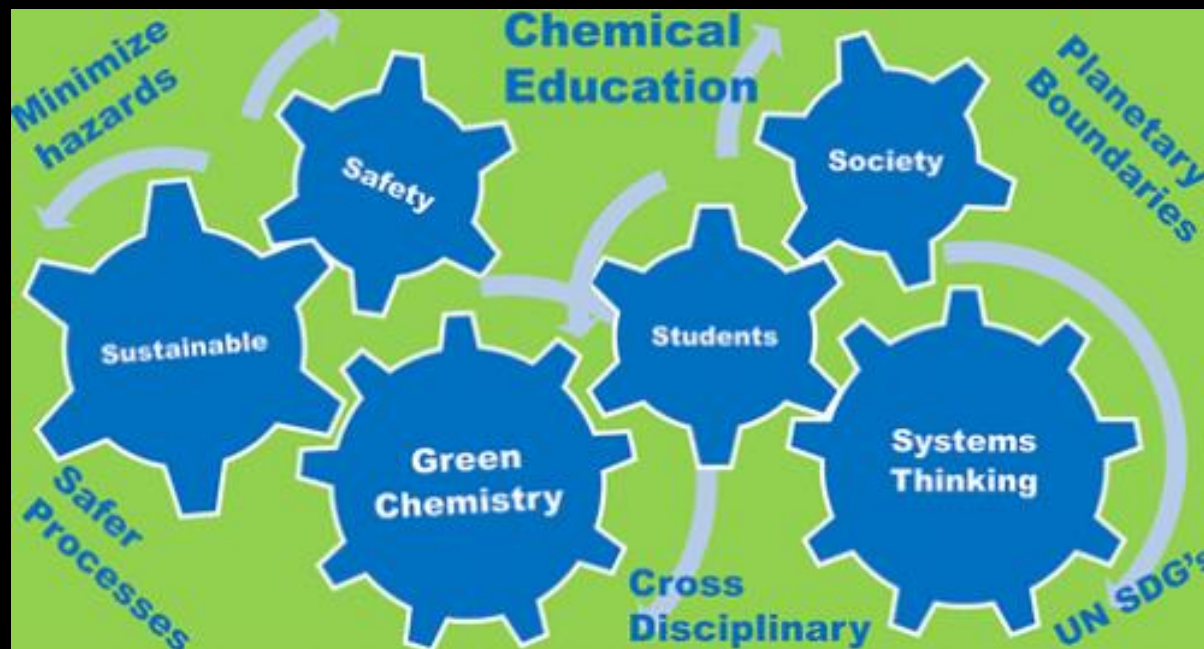


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Vol 96, Issue 12, Dec 2019

SYSTEMS THINKING IN GENERAL & GREEN CHEMISTRY

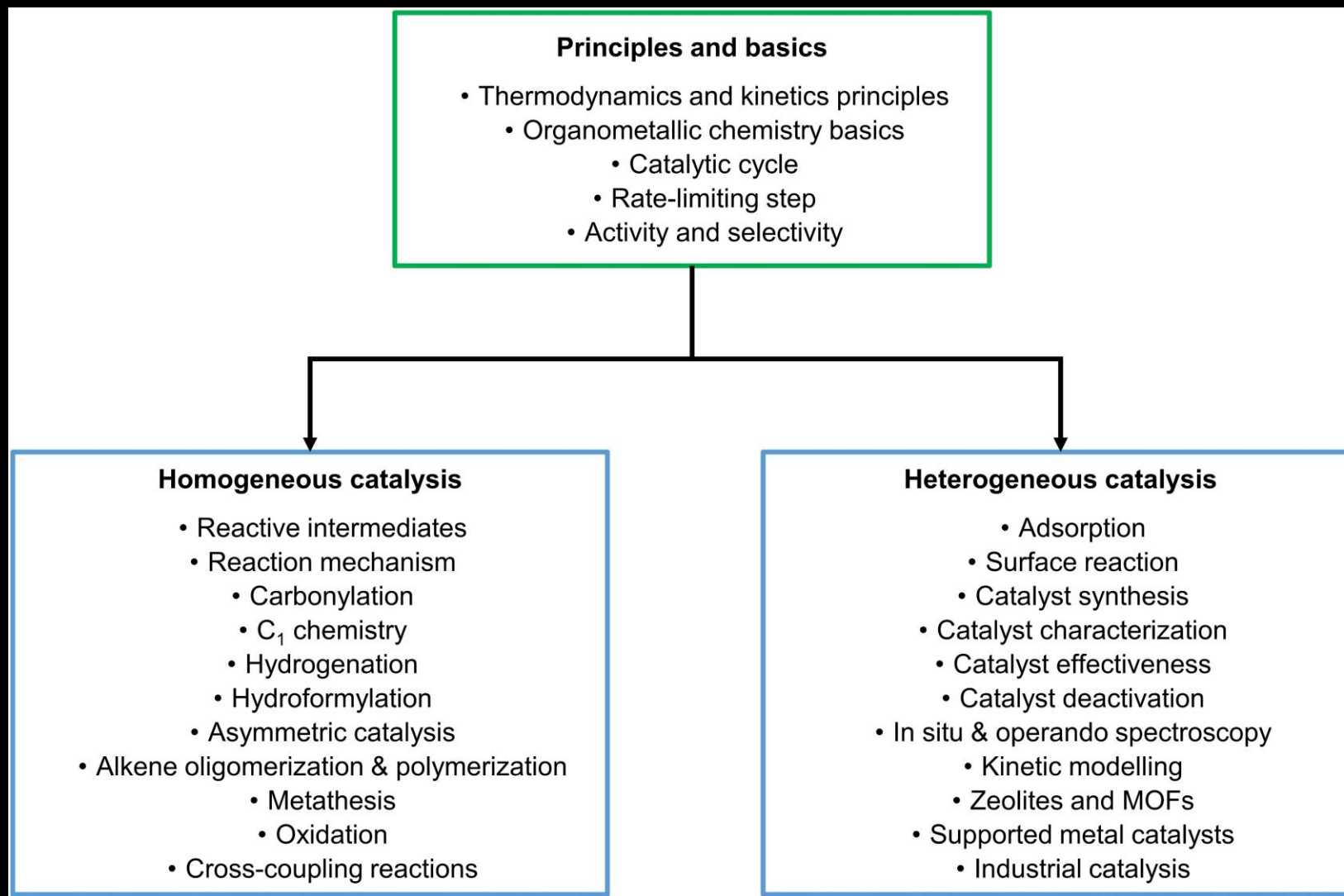


Mahaffy et al., *J. Chem. Ed.*, 96, 12, 2730-2741 (2019)



Aubrecht et al., *J. Chem. Ed.*, 96, 12, 2872-2880 (2019)

CATALYSIS COURSE CONTENT



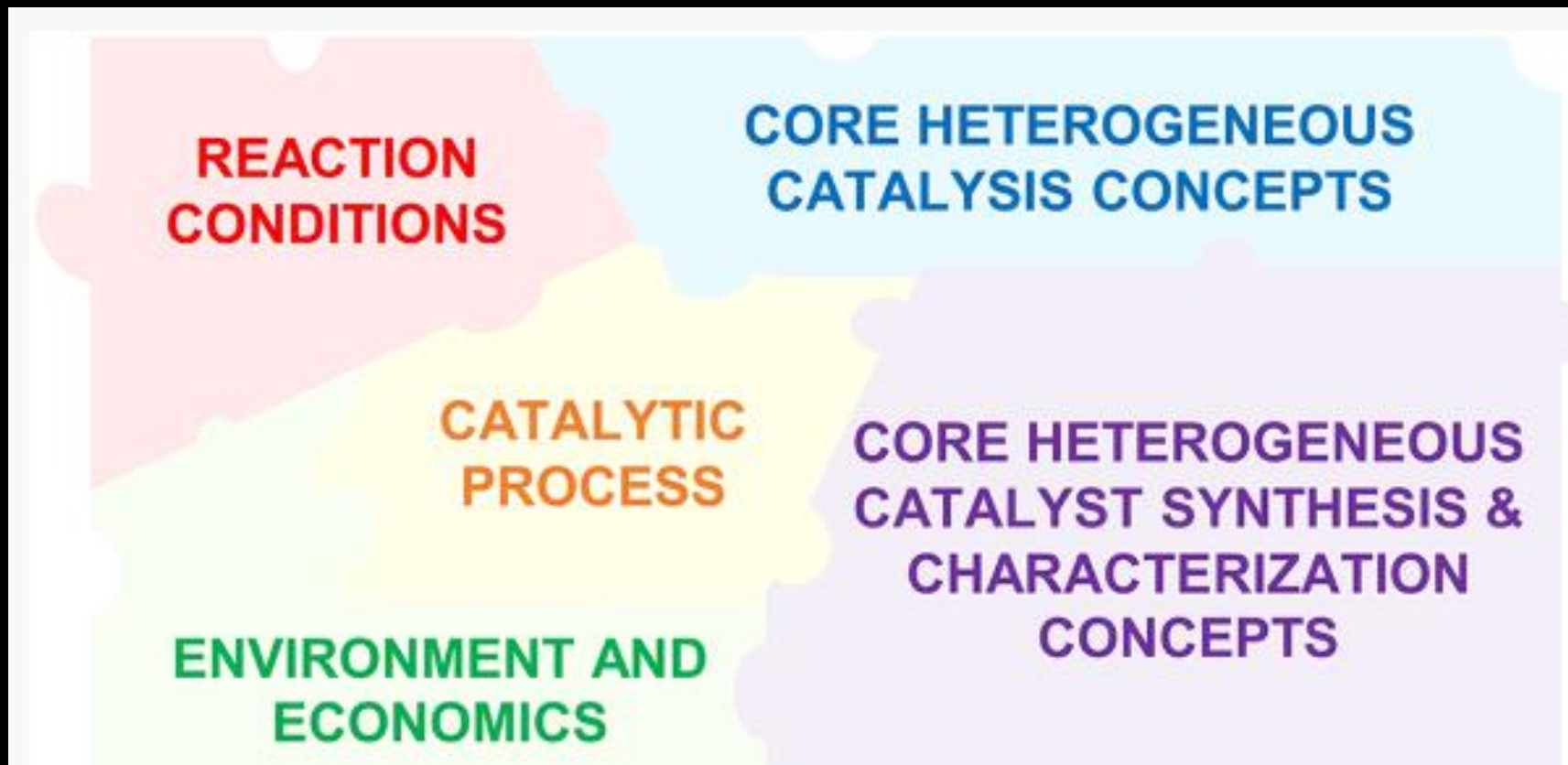
LEARNING OBJECTIVE

Students will be able to apply systems thinking to catalysis

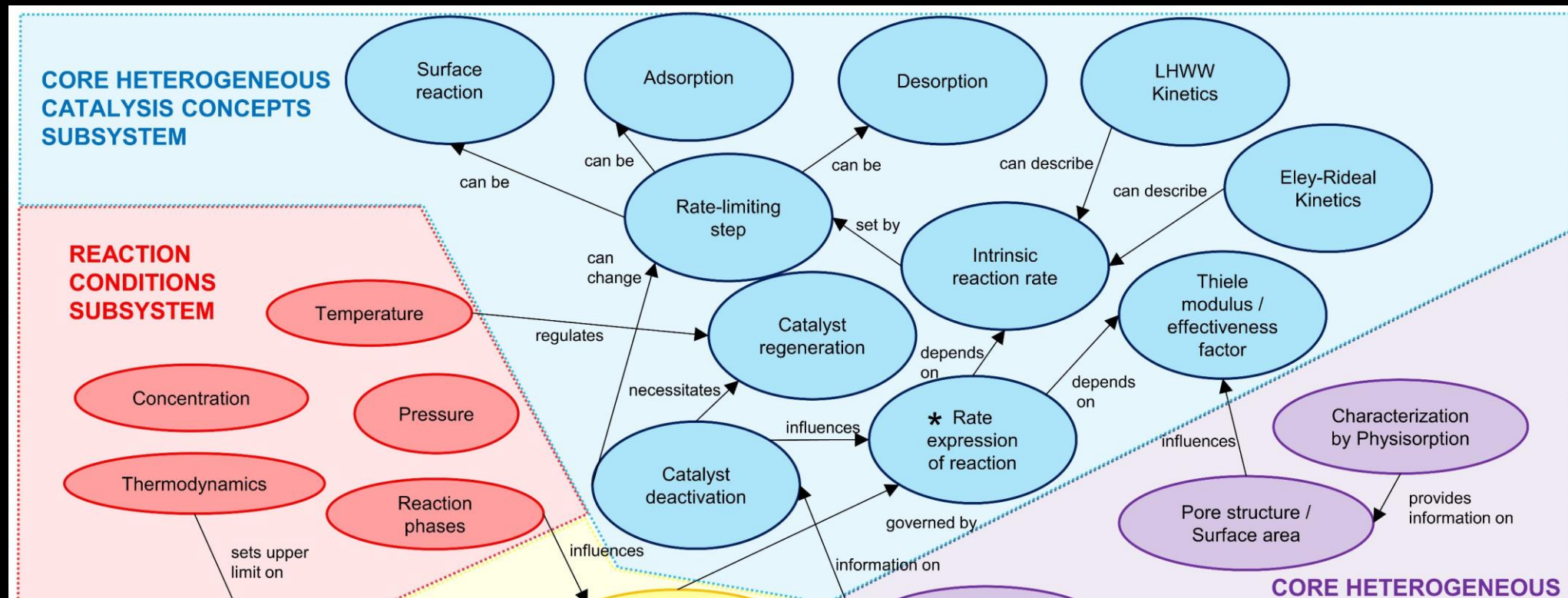
to better understand fundamental catalytic processes and underlying physical and physical chemical mechanisms

that leads to the design of better and more sustainable catalysts and catalyst systems

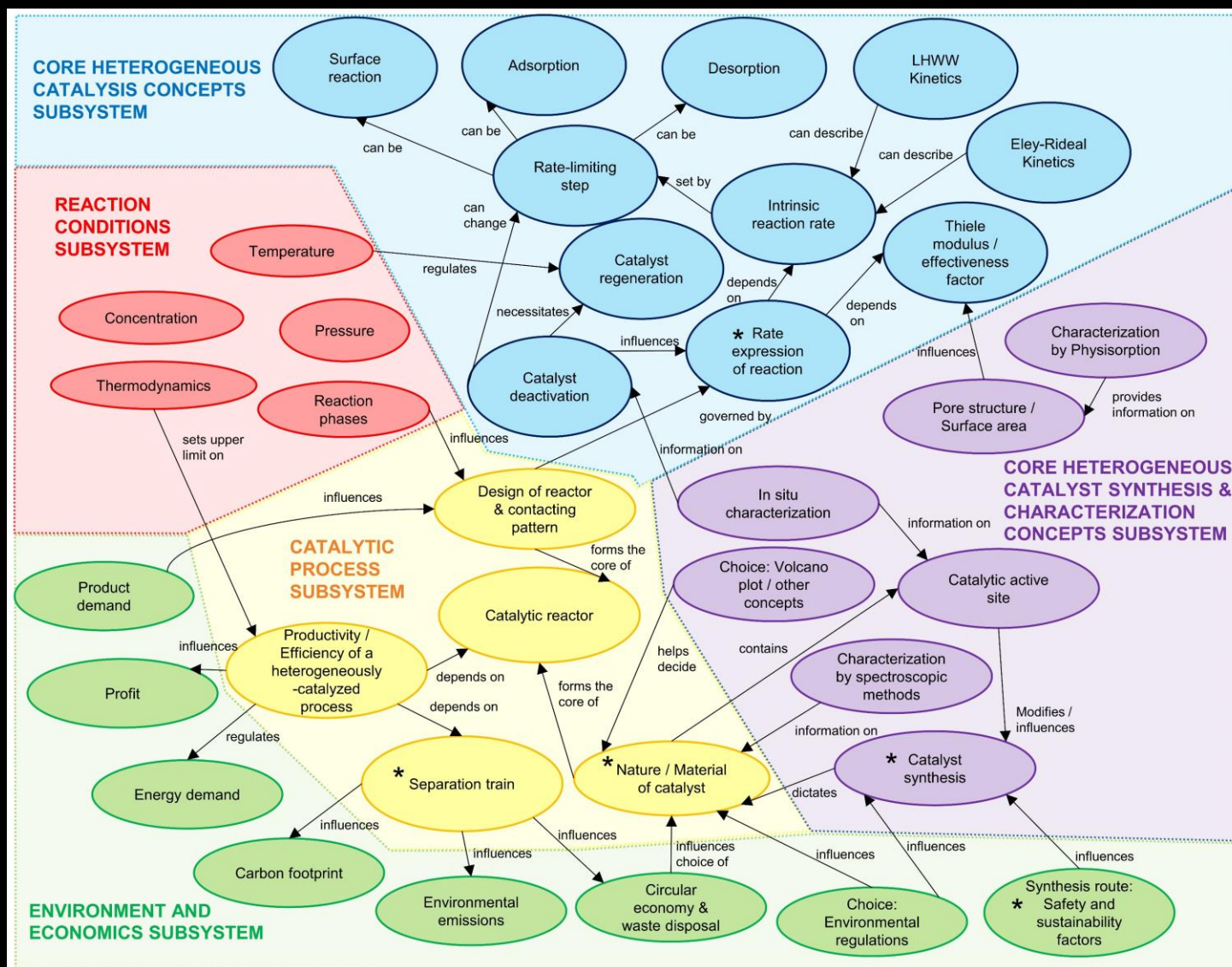
GRAPHICAL TOOLS FOR SYSTEMS THINKING IN CATALYSIS



SYSTEM-ORIENTED CONCEPT MAP FOR HETEROGENEOUS CATALYSIS

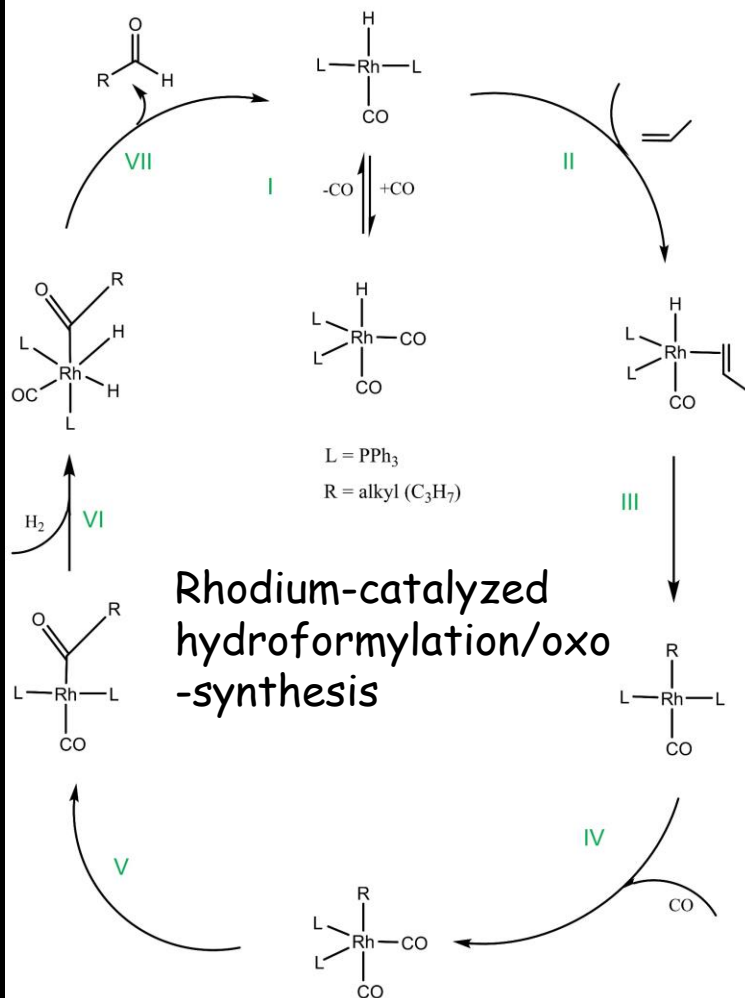


SYSTEM-ORIENTED CONCEPT MAP FOR HETEROGENEOUS CATALYSIS



LEARNING ACTIVITIES FOR SYSTEMS THINKING IN CATALYSIS

Think-Pair-Share activity worksheet



Effect on individual reaction steps

Parameter	Effect on Reaction Step No.						
	I	II	III	IV	V	VI	VII
[PPh ₃]							
p _{CO}							
[olefin]							

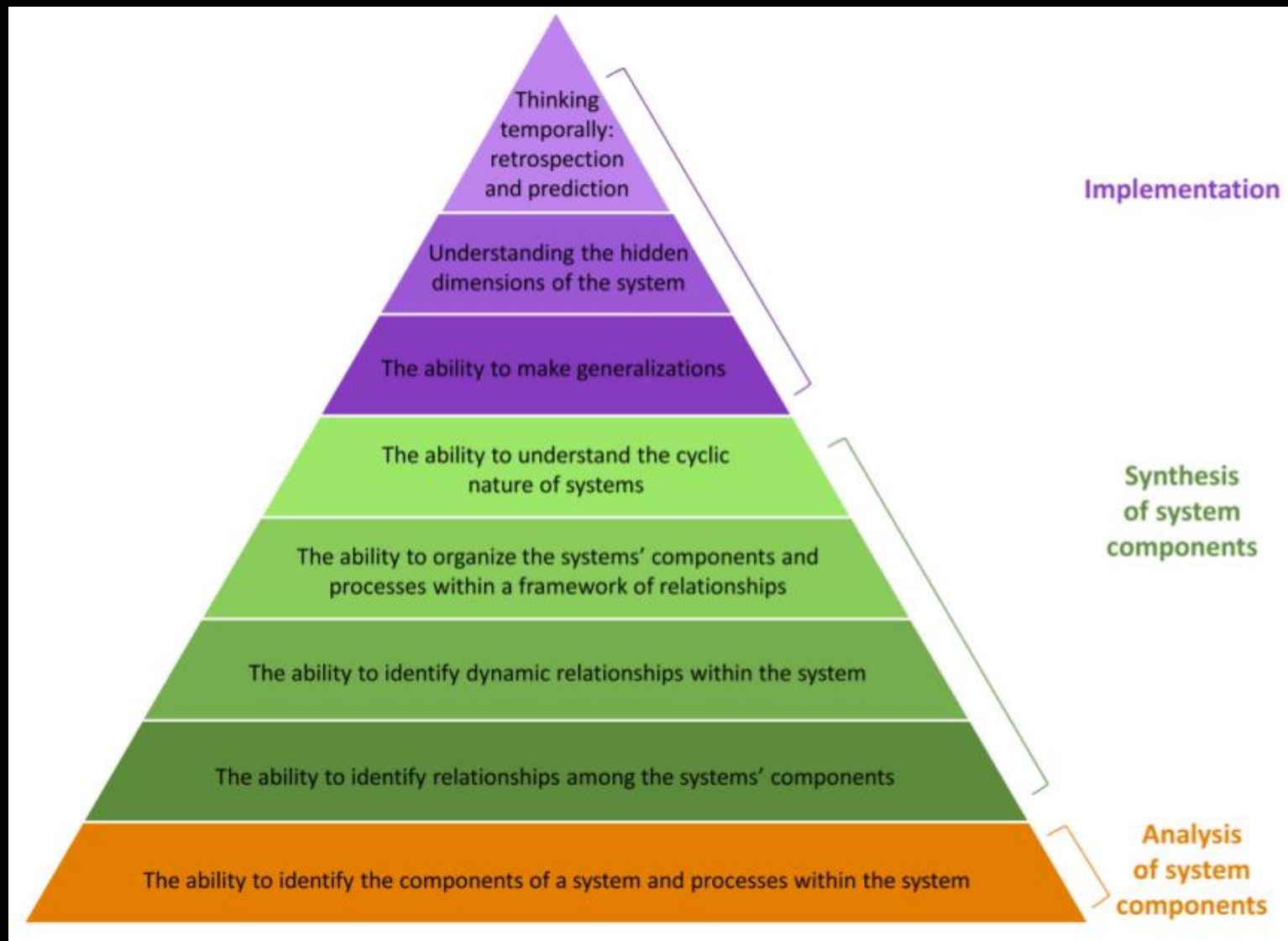
Systemic effects

Parameter	Effect on system-level properties	
	Overall rate of reaction	Product Selectivity (linear/branched alcohol)
[PPh ₃]		
p _{CO}		
[olefin]		

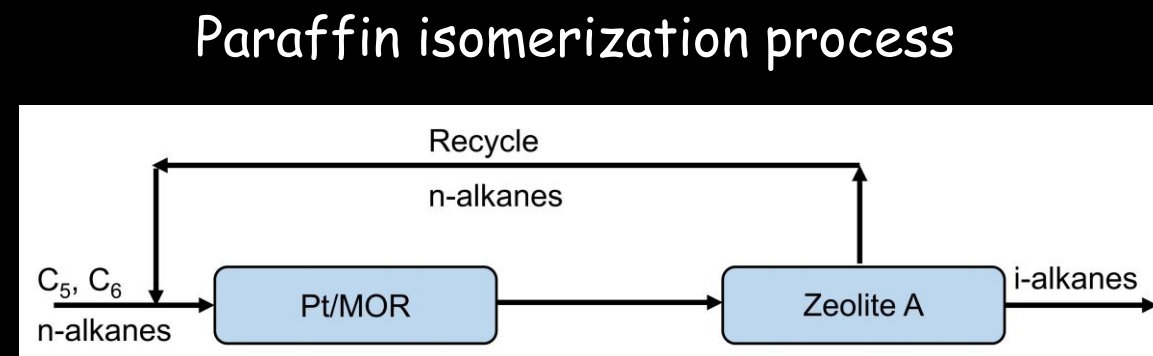
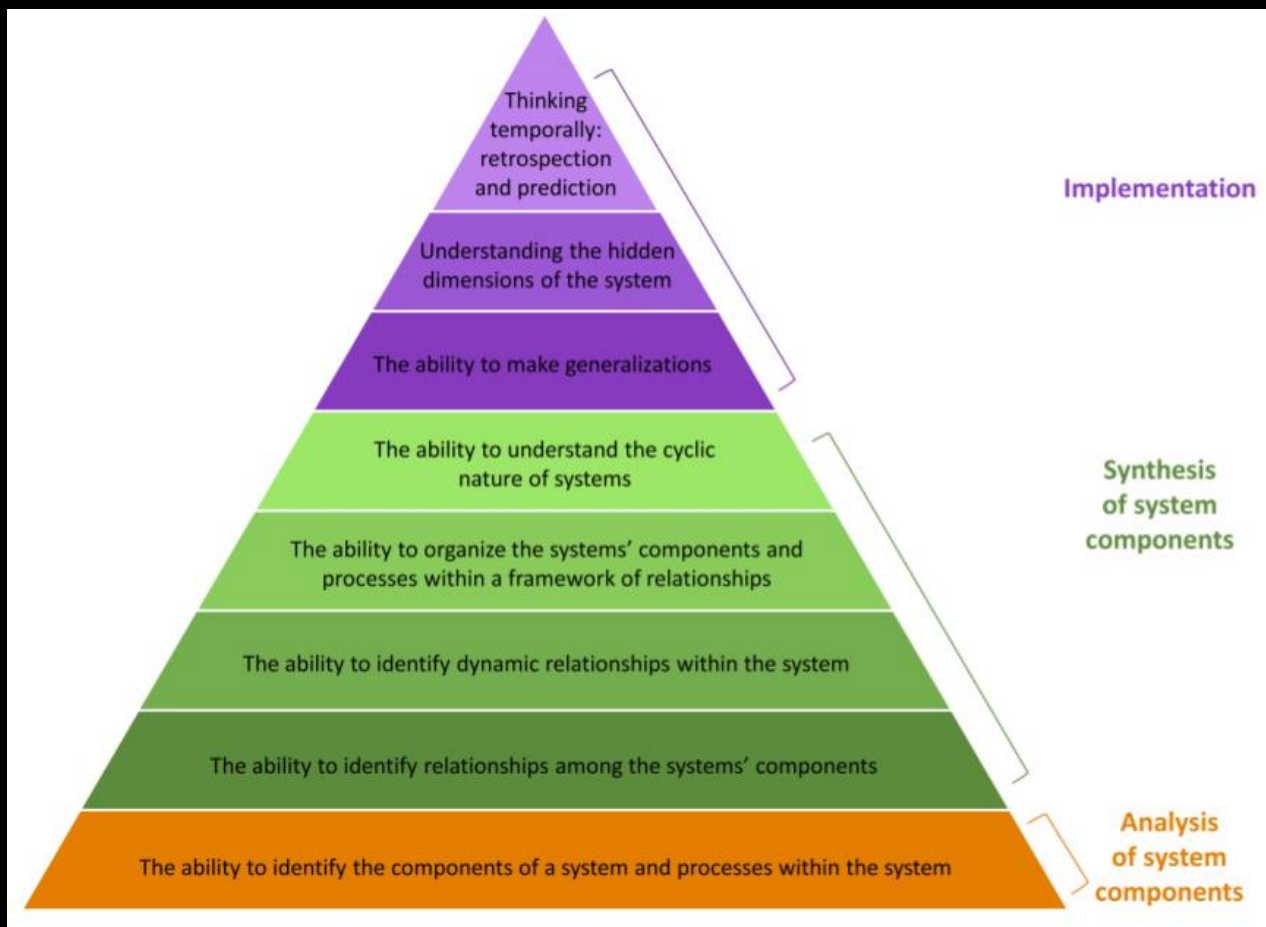
System-environment interactions and considerations

	Cost & Availability	Environmental impact	Next-generation catalytic process?
Rh			
CO			
Olefin			

STUDENT ASSESSMENTS: SYSTEMS THINKING HIERARCHICAL MODEL



STUDENT ASSESSMENTS: SYSTEMS THINKING HIERARCHICAL MODEL



CONCLUSIONS

- ✓ Better learning outcomes
- ✓ Implications of catalysis in matters of global importance

(Re)designing catalysis curriculum by following the principle of constructive alignment

- (Re)framing of intended learning objectives (ILOs)
- Greater use of graphical tools
- Design of learning activities that foster systems thinking skills
- Formulate assessments based on the systems thinking hierarchical model