An **Energy Frontier Research Center**

supported **by the**

U.S. Department of Energy,

Office of Basic Energy Sciences

Dion Vlachos, Director

Major Research Goals

Transform biomass and/or its derivatives into valuable chemicals, fuels and electricity through a fundamental understanding of the chemistry and catalyst performance

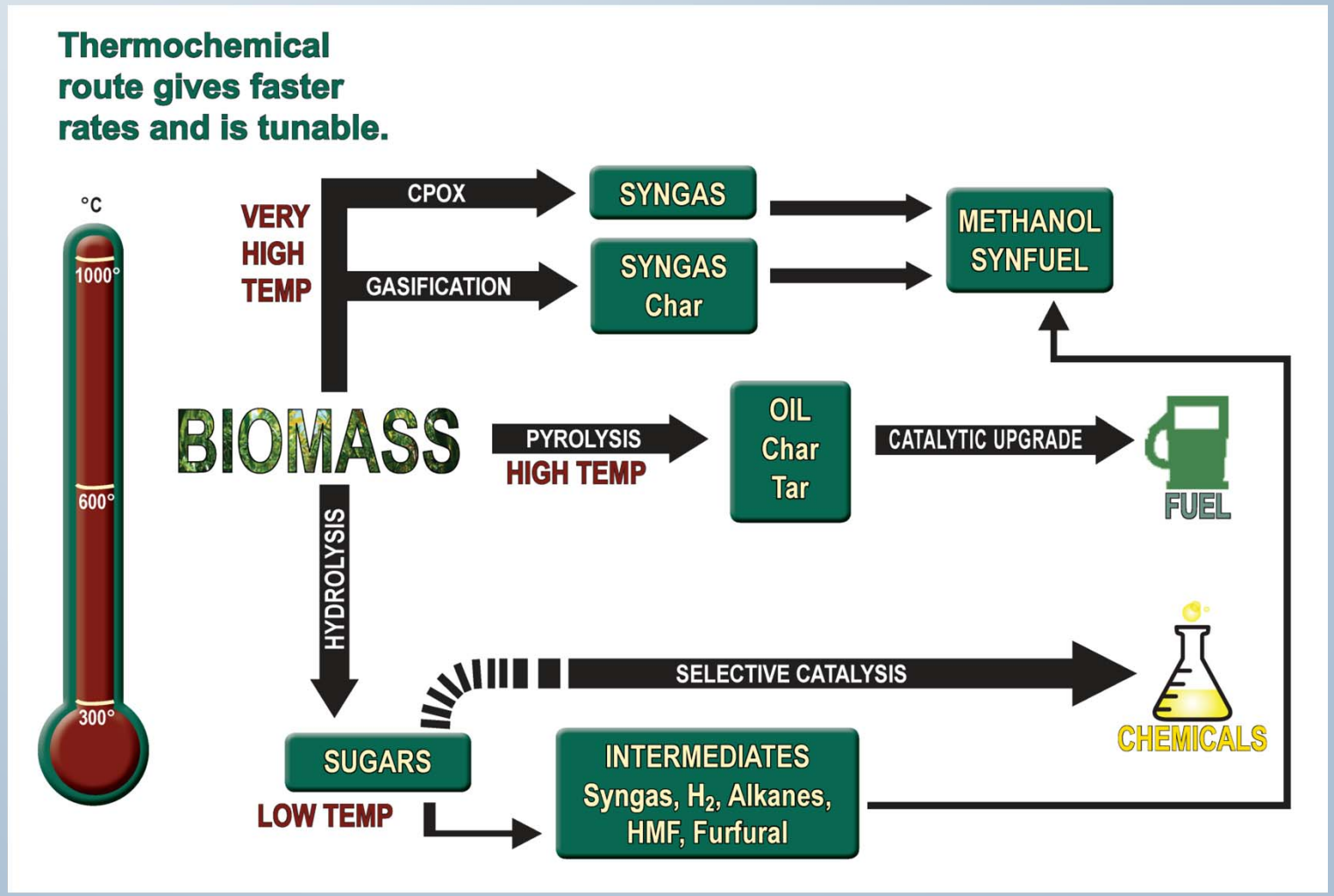
Design novel hierarchical multiscale materials with nanoscale resolution suitable for processing derivatives from complex, multiphase media of biomass to ensure efficient, highly selective and benign processes

Promote catalyst design and technology advancement through novel theoretical and multiscale simulation platforms and cutting-edge characterization tools

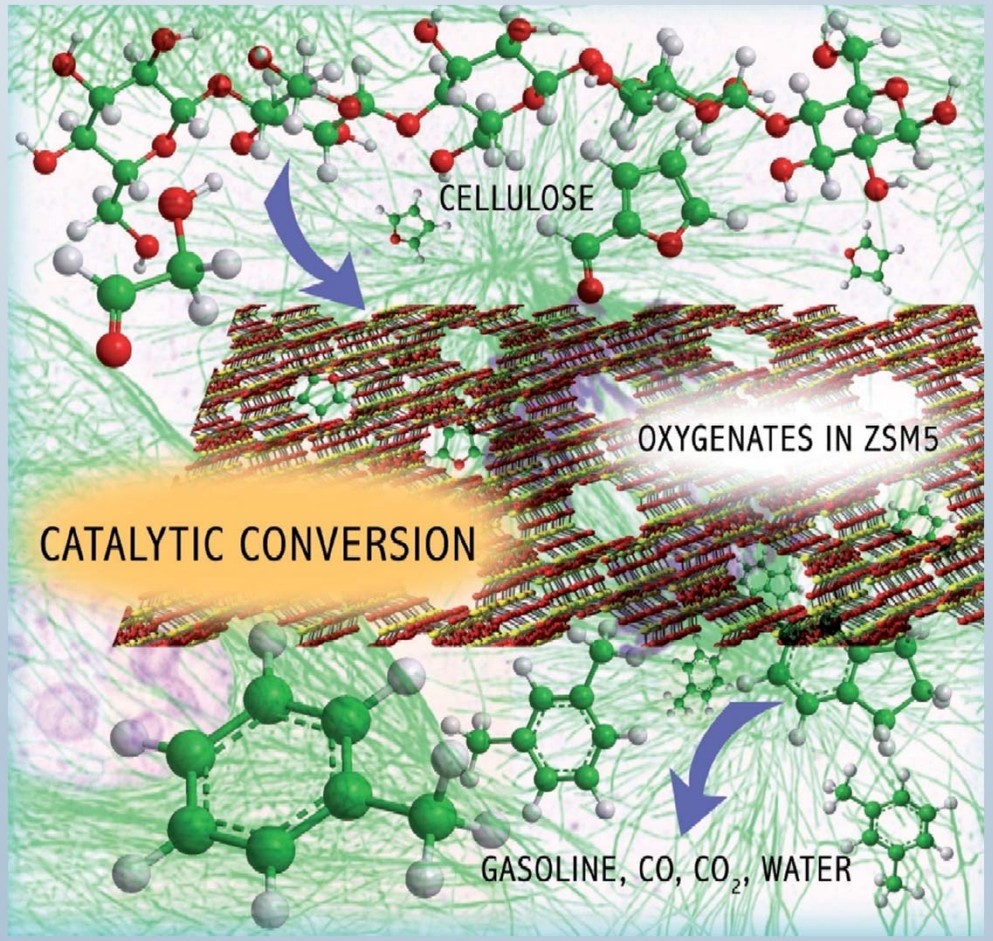
Grand Challenges

- Lignocellulosic biomass decomposition (e.g., pyrolysis) leads to **coking** and the process is **slow**
- **Complex feedstock** renders fundamental studies difficult
- Biomass and its derivatives are **over-functionalized molecules**
  - *Selectivity* is critical
  - Chemical transformations require fundamental understanding of chemistry and catalyst performance (currently lacking)
- Processing of biomass derivatives occurs in a **complex environment**
  - Low volatility and thermal stability require *solution chemistry*
    - ✓ Typical supports (e.g., Al_2O_3, SiO_2) dissolve in water
    - ✓ Acid-based chemistry (e.g., HCl) is environmentally harsh
    - ✓ Models do not exist

Thermochemical Transformation of Lignocellulosic Biomass



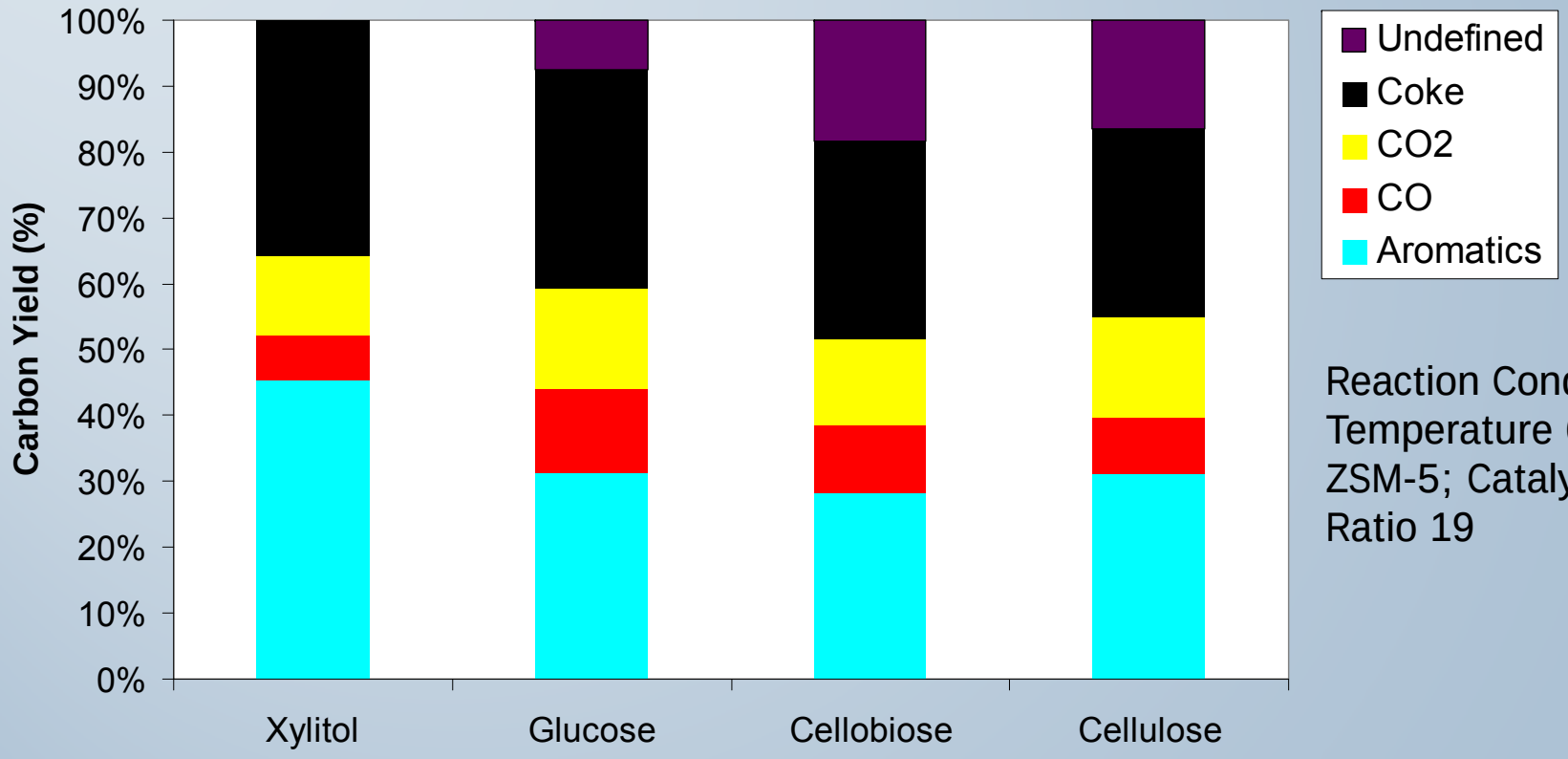
Catalytic Fast Pyrolysis



- Solid biomass converted into aromatics in a single reactor at short residence times
  - Liquid fuel that fits into existing infrastructure
  - Low cost, recyclable zeolite catalysts

Carlson et al., Green Gasoline by Catalytic Fast Pyrolysis of Solid Biomass-derived Compounds, *ChemSusChem*, 1, 397-400 (2008)

Catalytic Fast Pyrolysis: Overall Yields



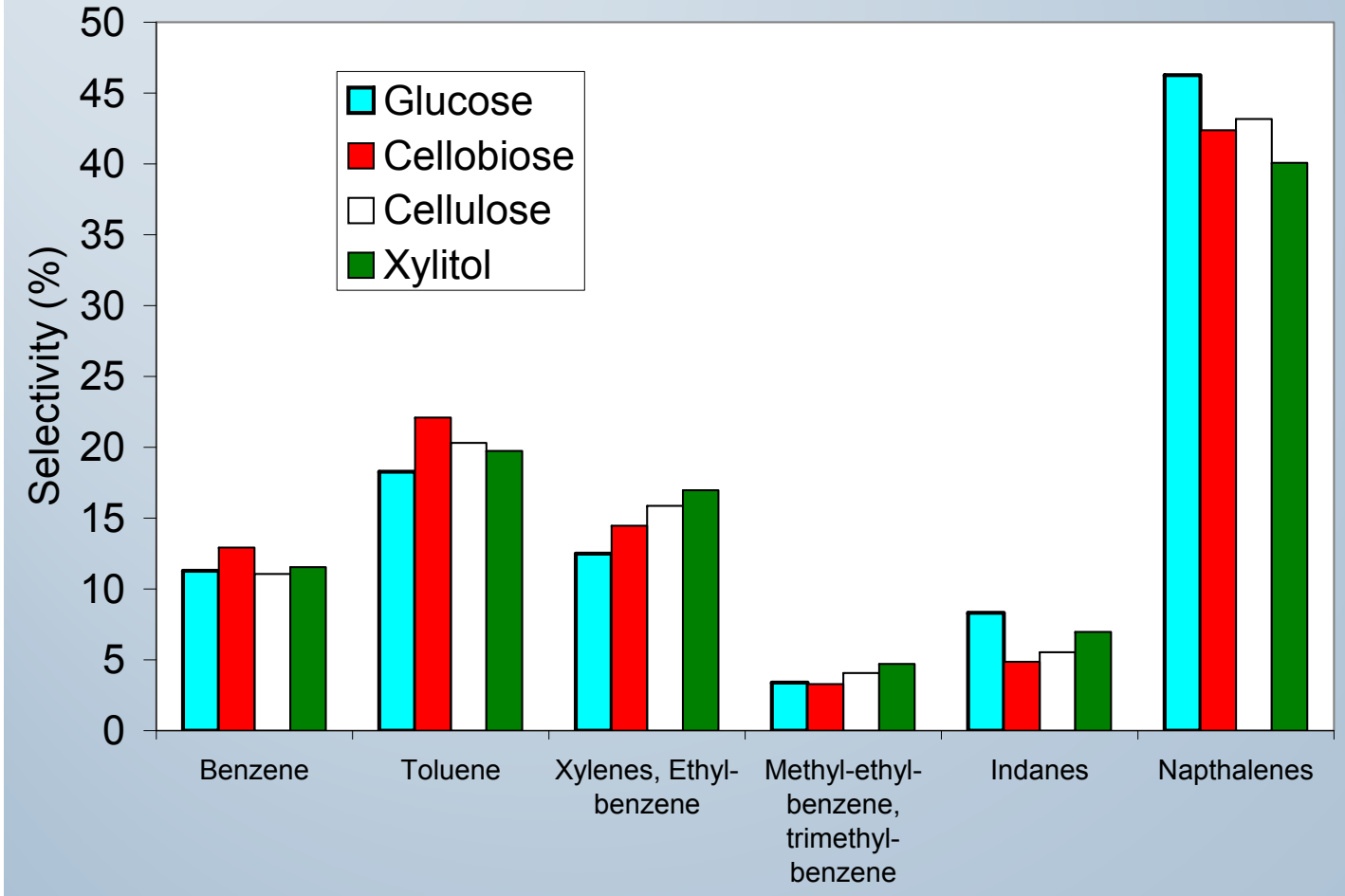
Reaction Conditions: Temperature 600°C; ZSM-5; Catalyst/Feed Ratio 19

Maximum Yield:

$C_6O_6H_{12} \rightarrow 12/22\ C_7H_8$ (63 % Yield) + 48/22 CO (36 % Yield) + 84/22 H_2O

Carlson, Vispute, and Huber, Green Gasoline by Catalytic Fast Pyrolysis, *ChemSusChem*.

Gasoline Range Aromatics



- Octane number of aromatics is 110
- Aromatics can be blended at 25% level in gasoline
- Aromatics can be hydrogenated to other fuels
- BTX is more valuable than gasoline

G. Huber/UMass

Liquid Fuels from Carbohydrates

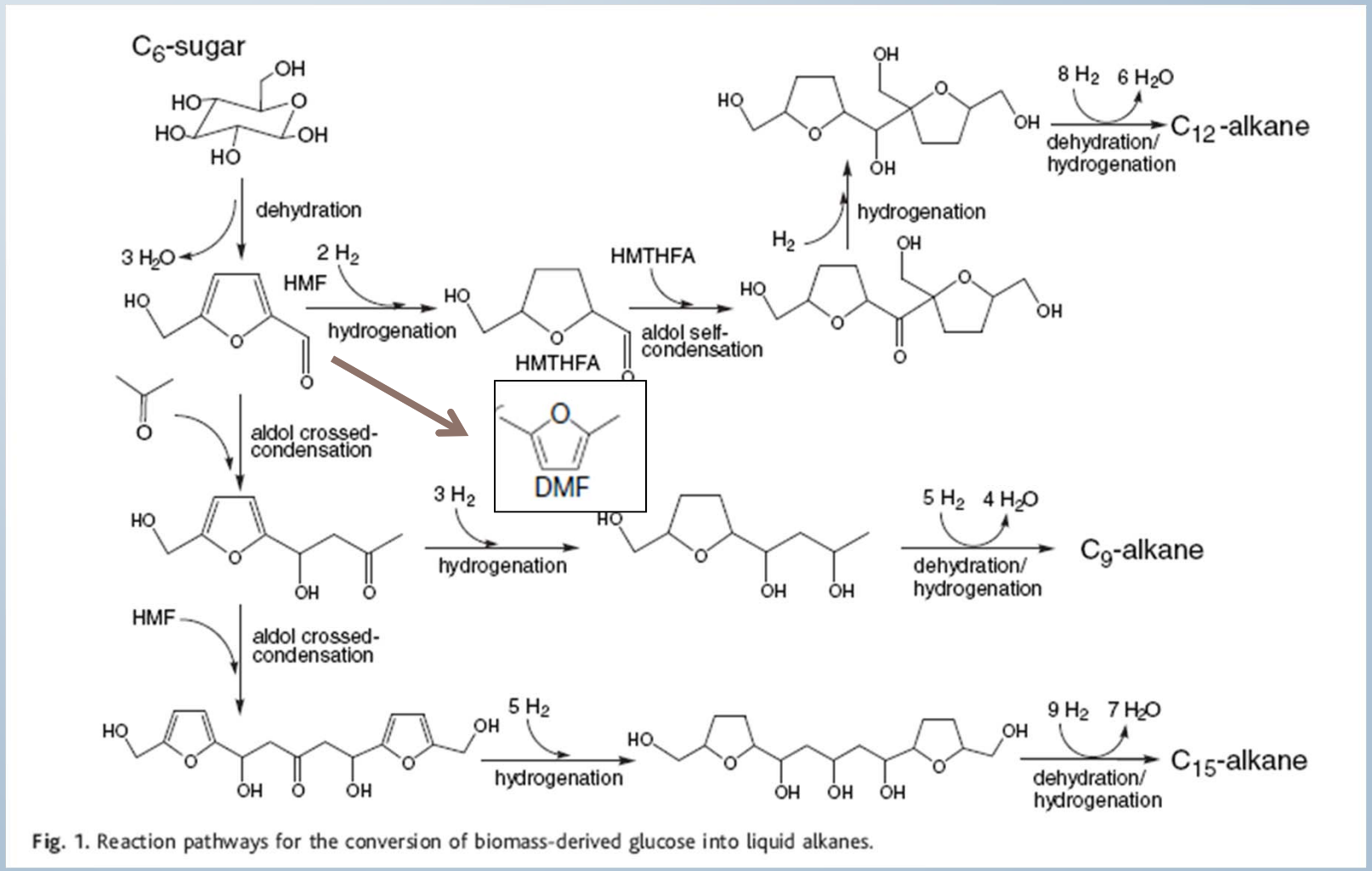


Fig. 1. Reaction pathways for the conversion of biomass-derived glucose into liquid alkanes.

George W. Huber, et al., *Science,* 308, 1446 (2005)