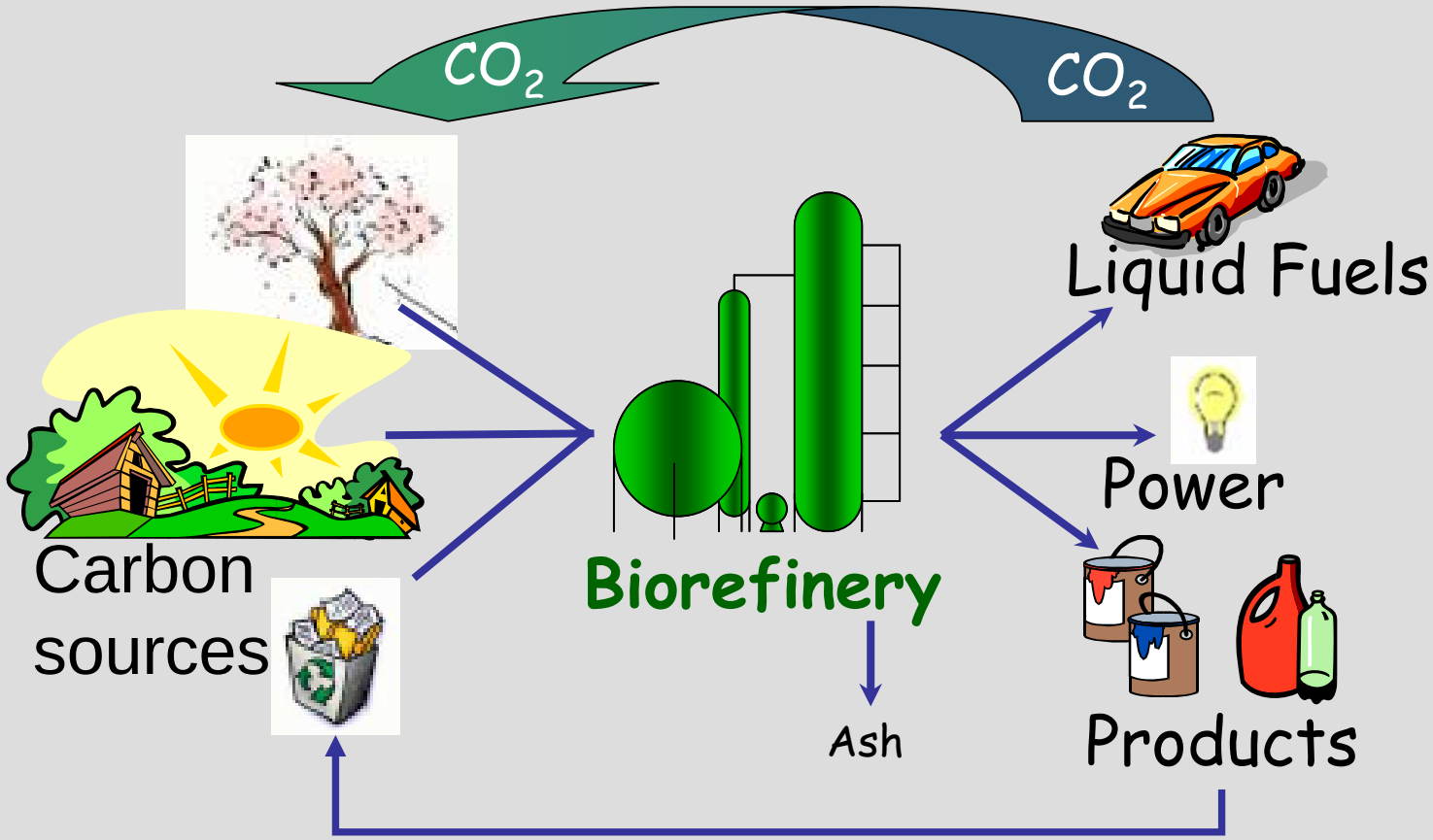
Overview of Catalytic Biomass Conversion Activities At PNNL

For IIC Open House

Jim White

15 & 16 March 07

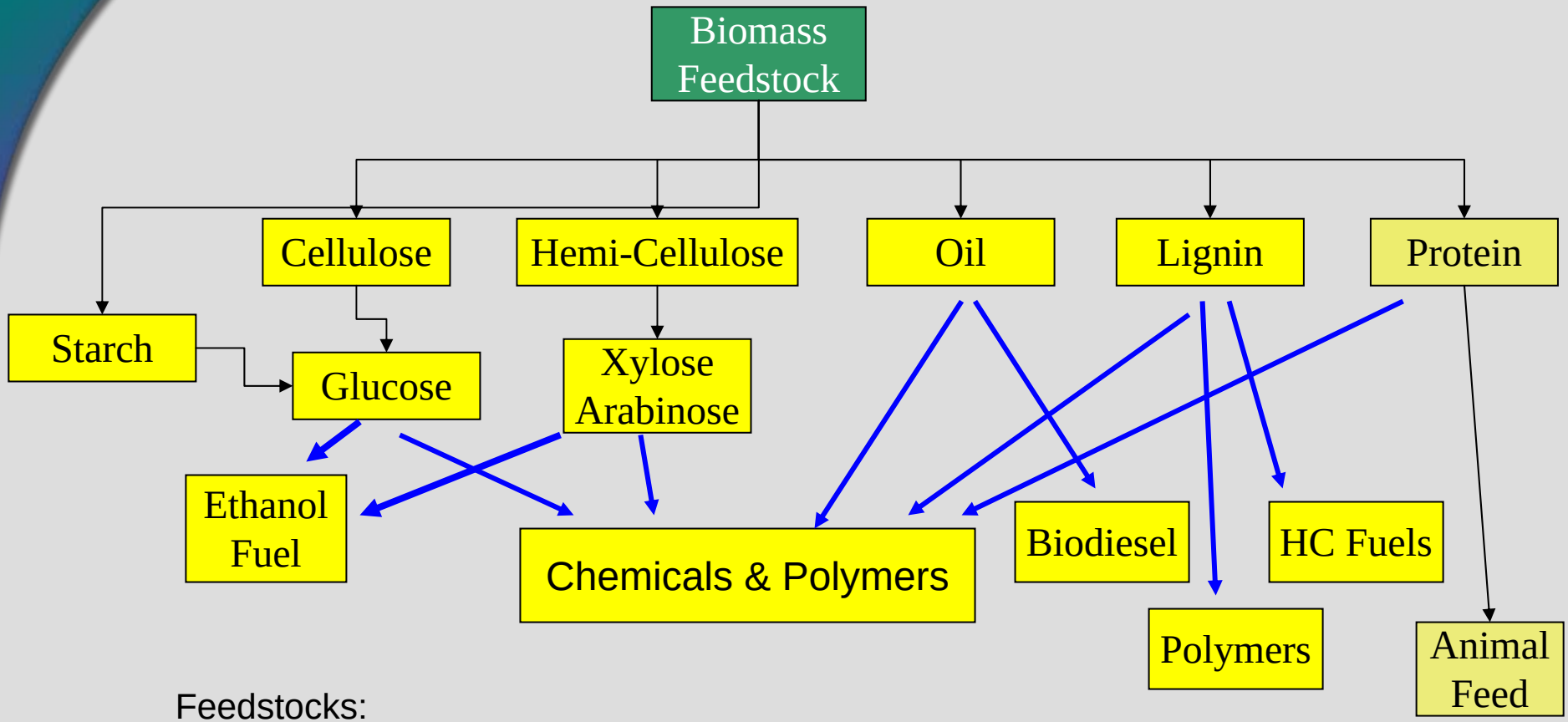


CONCEPTUAL BIOREFINERY

Program Strategy

- Analysis is used to identify major cost barrier areas in each element of the program
- Research is dedicated to overcoming these barriers and reducing the cost of each process as well as the final integrated biorefinery
- Program is driven by private - public partnerships to ensure integrity of the program
- Regular reviews are undertaken to ensure progress and fiduciary responsibility
- Program is based on both near term and long R&D objectives

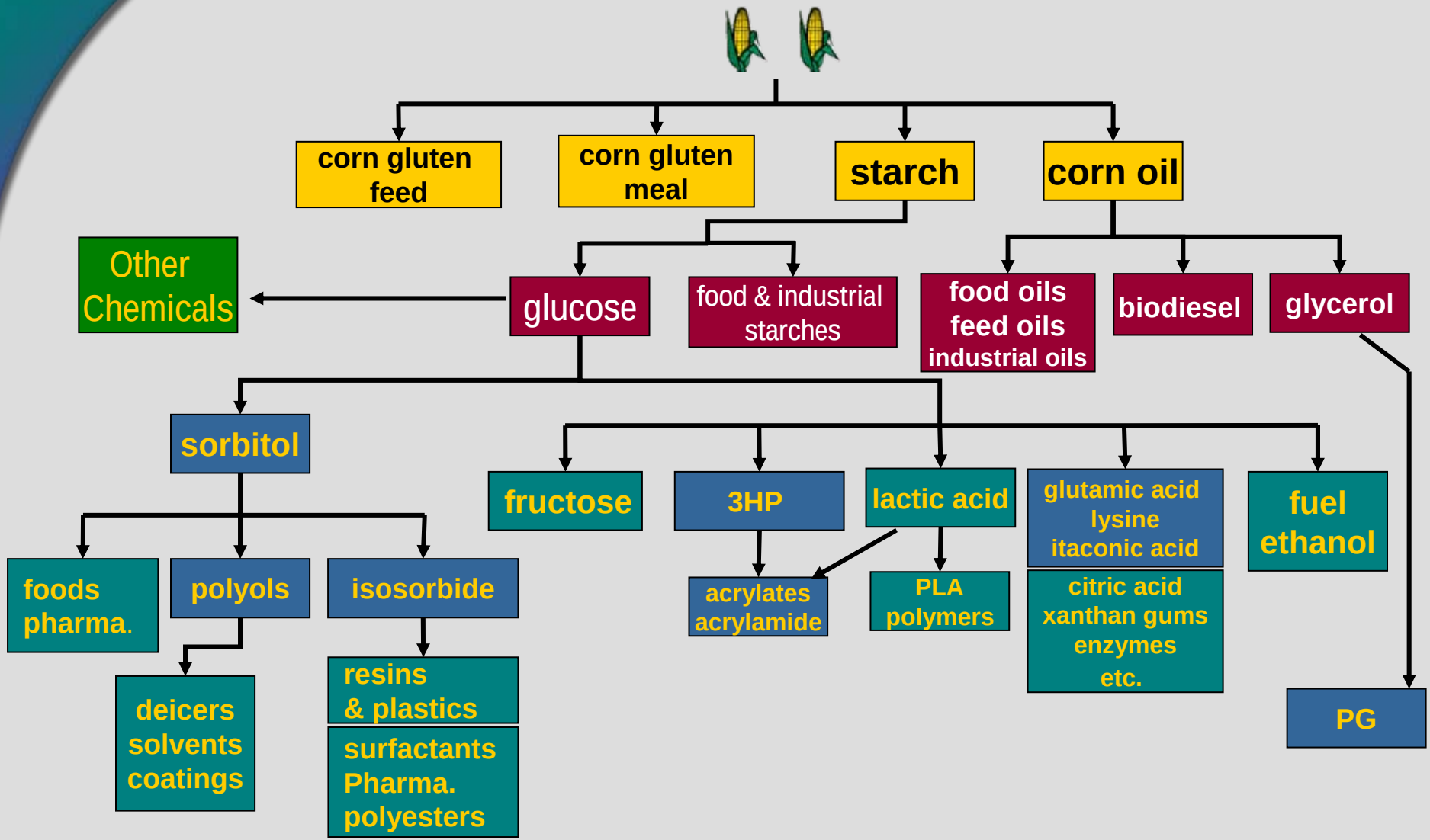
Potential Feedstocks



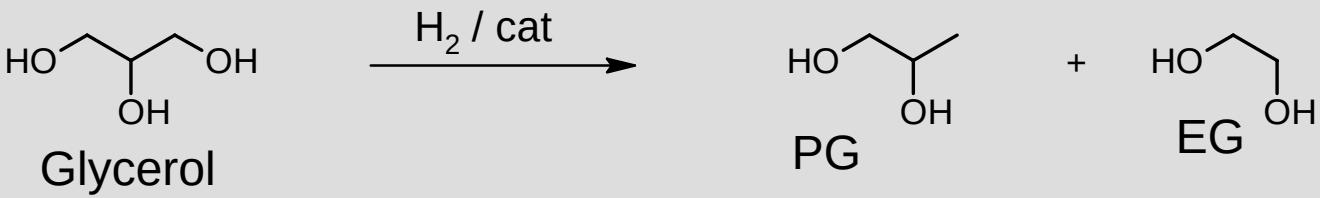
Feedstocks:

- Rotational Crop Residues (stover, wheat straw, rice straw etc.)
- Forest Thinnings and Wastes
- Oil crops
- Traditional Rotational & New Crops
- Energy Crops (switch grass, poplar etc.)

Example of a Bio-refinery: Corn Wet Mill



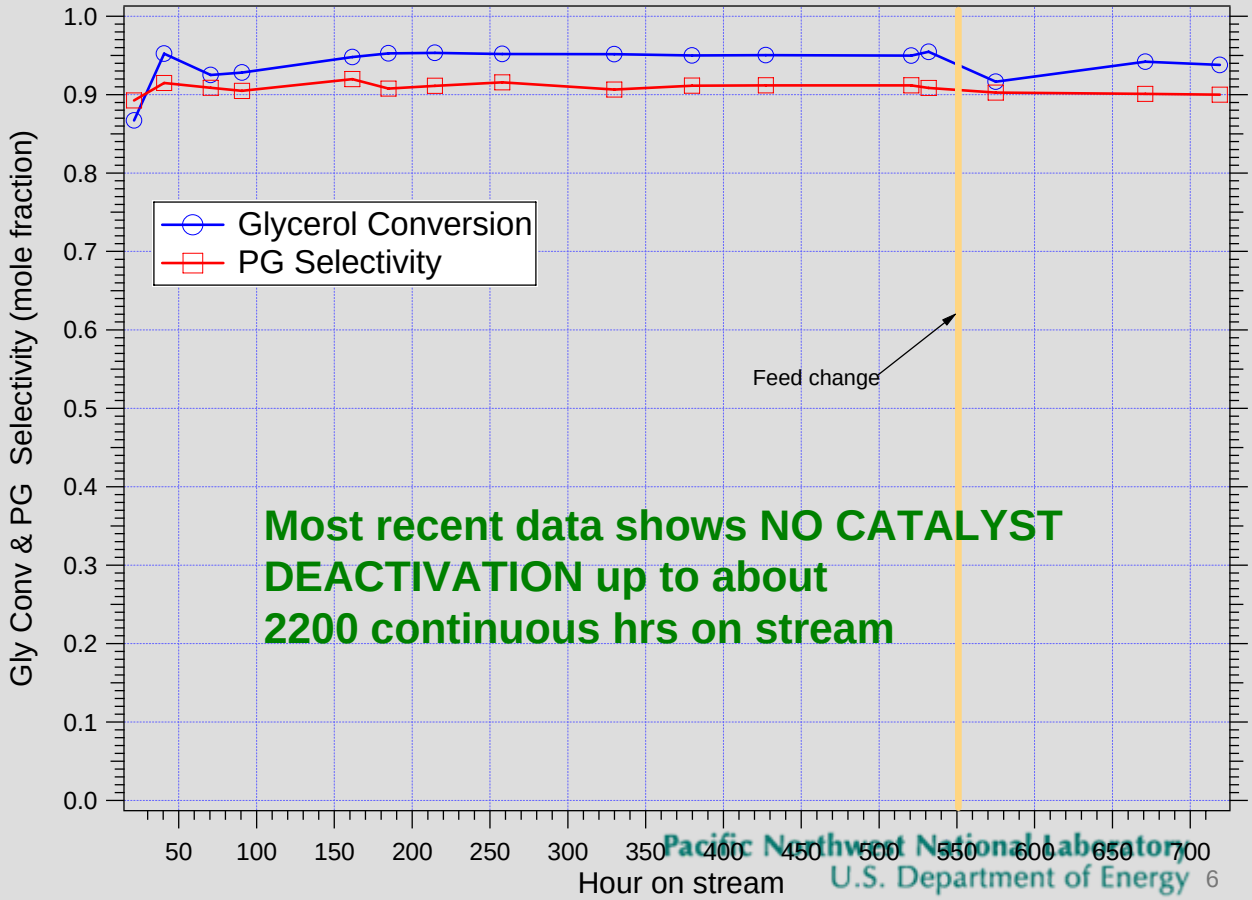
Glycerol to PG chemistry—the bottom line



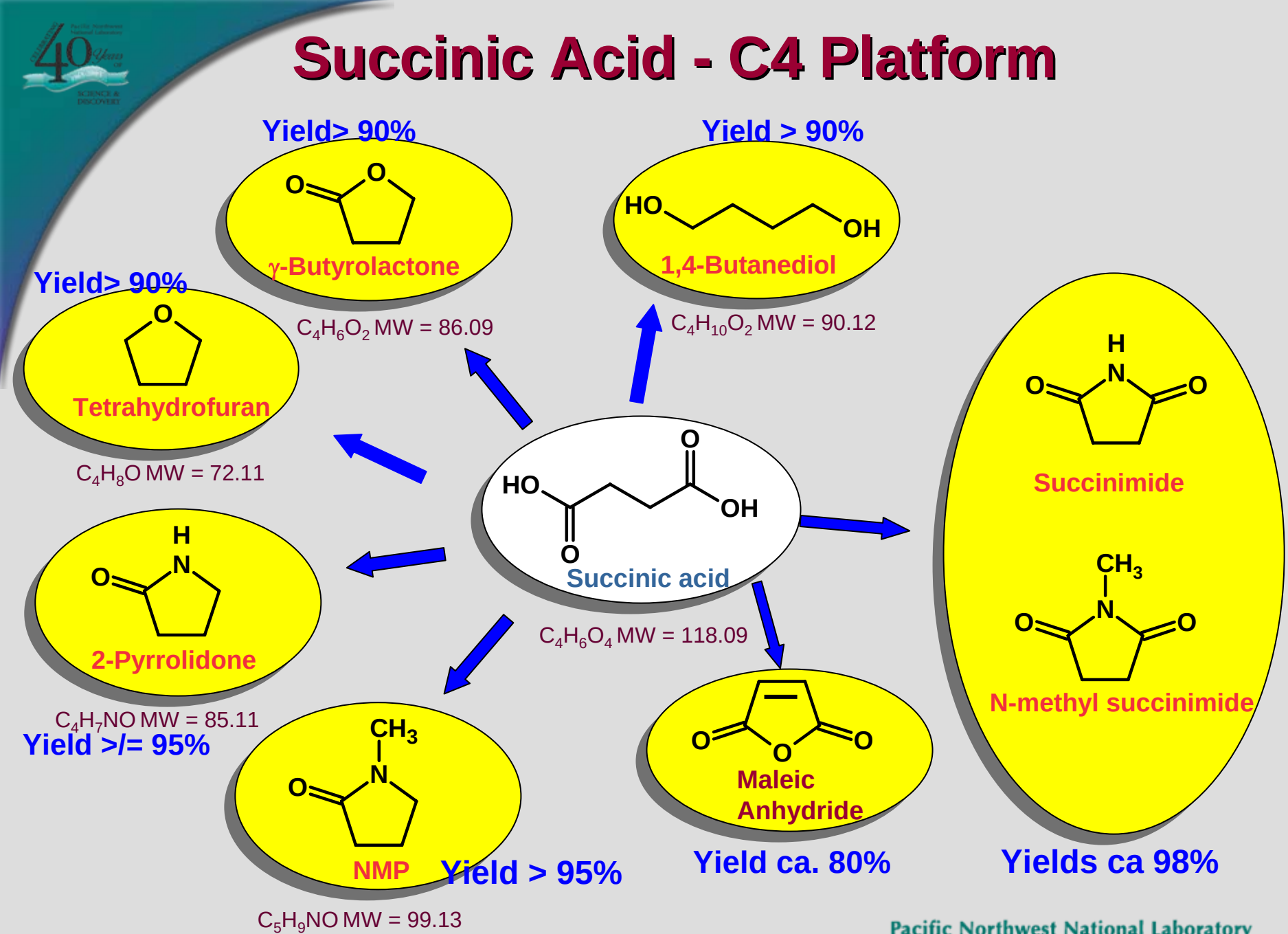
PG Market is 3.5 billion lbs globally

1 billion gallons of biodiesel affords about 700 million pounds of glycerol

PG Process requires catalysts with multiple functionality able to withstand rather severe hydrothermal conditions



Succinic Acid - C4 Platform

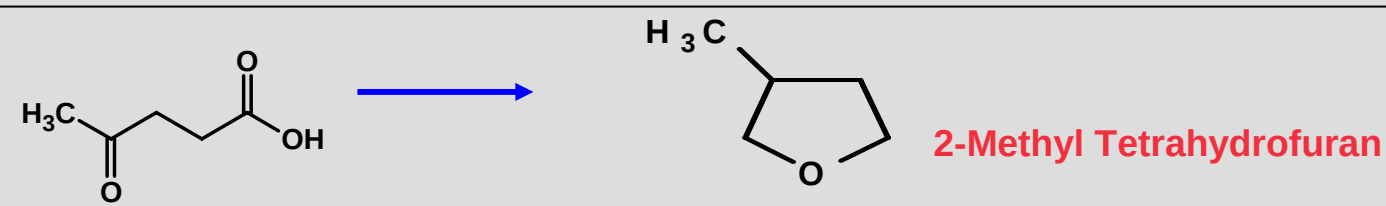


OTHER CATALYTIC PROJECTS by CARBON

C-3

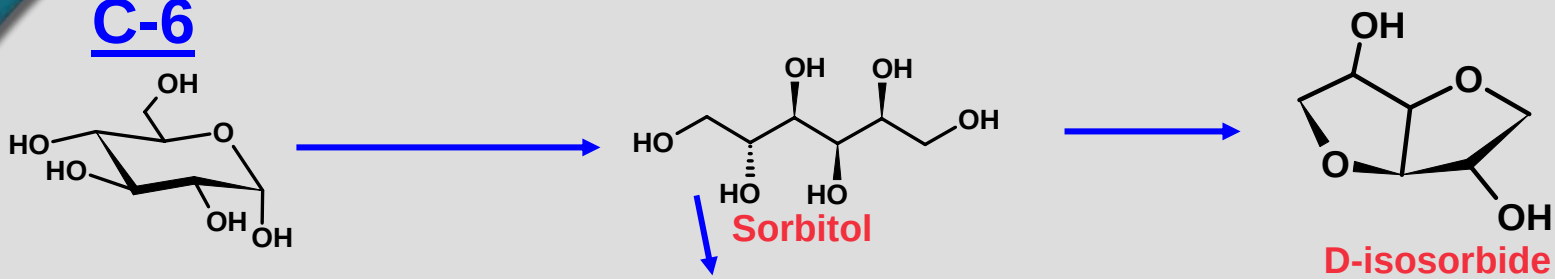
C-5

Corn Fiber → Xylitol/Arabitol → EG, PG & Glycerol

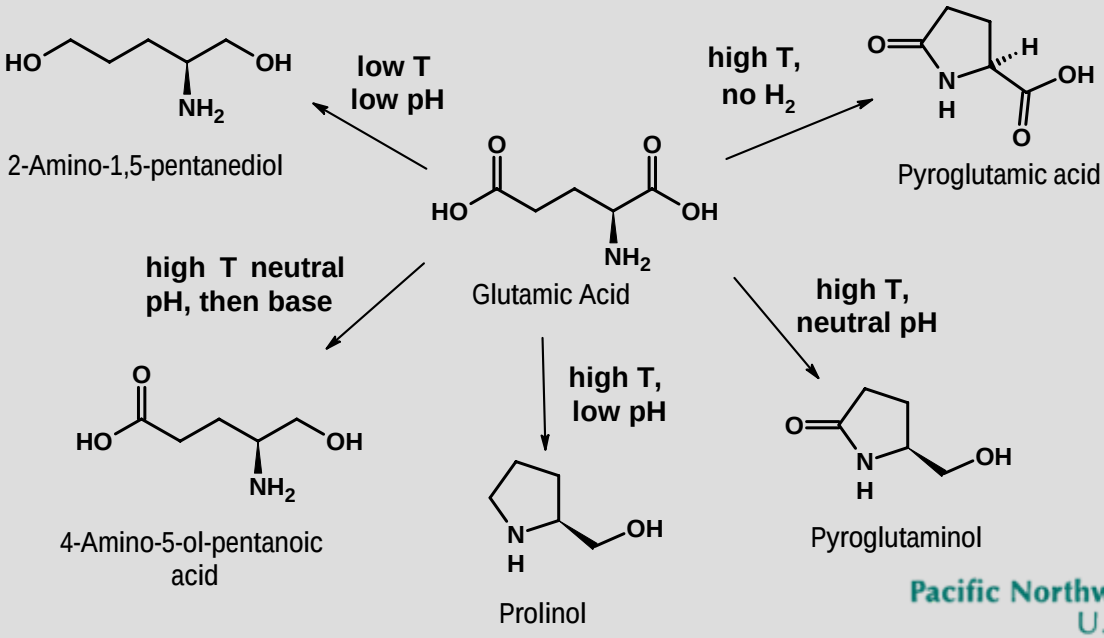


OTHER CATALYTIC PROJECTS by CARBON

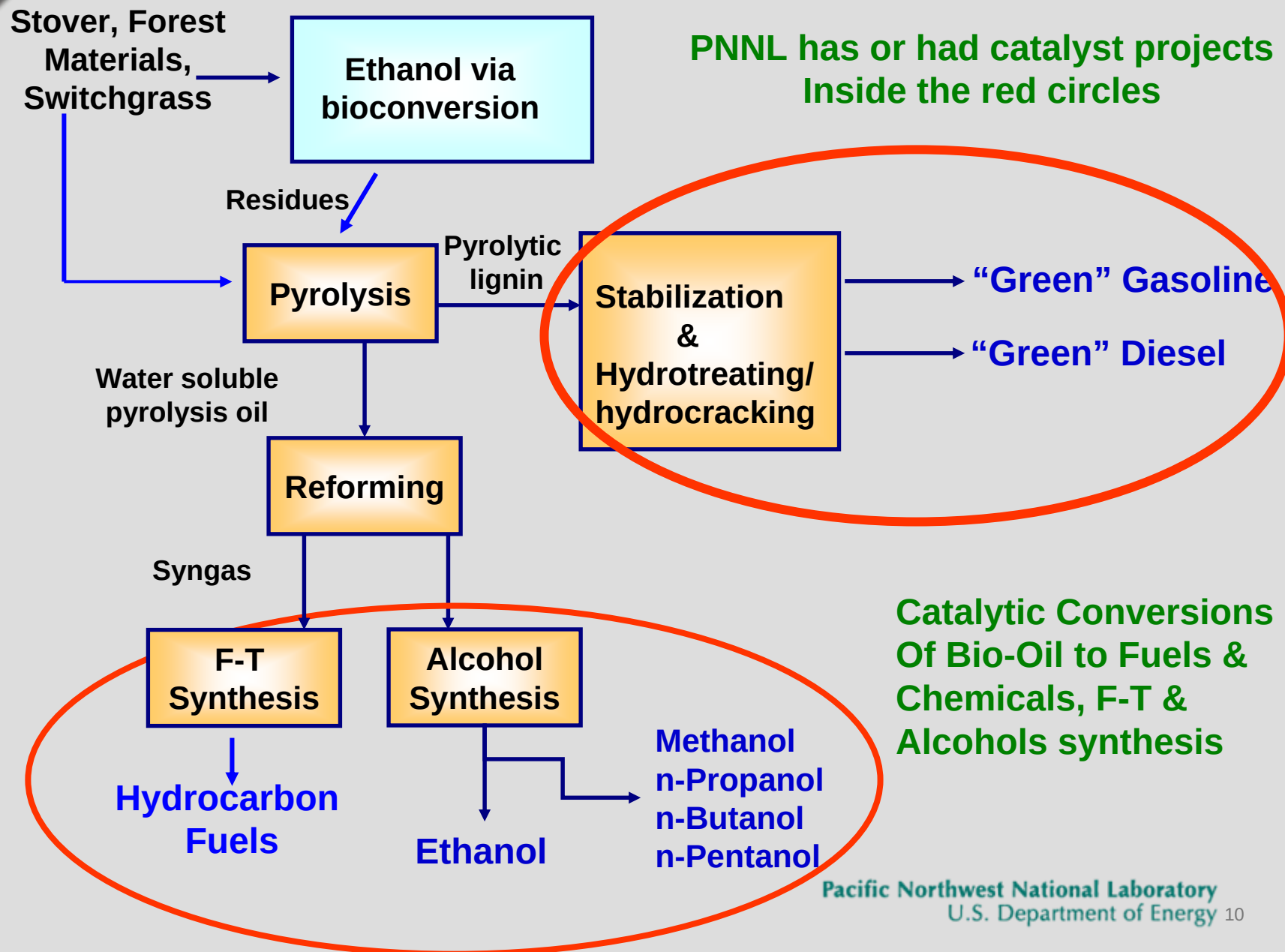
C-6



C-5 AMINO ACID CONVERSION



Integrated Ethanol, Pyrolysis and Mixed Alcohols



PNNL has or had catalyst projects Inside the red circles

Catalytic Conversions Of Bio-Oil to Fuels & Chemicals, F-T & Alcohols synthesis

OTHER CATALYTIC PROJECTS by CARBON

C-X

Residues & Organic Wastes → **Wet Gasification** / **Catalyst Life Improvement** → **Medium BTU Fuel Gas**

Aqueous wastes clean-up yields fuel gas & clean water

Purification via Catalysis & chemistry →

Carbon Fiber
(Companion to ORNL CF program)

Low Cost carbon fiber for better fuel mileage via cars lightweighting

Combinatorial Catalysis

Not a just better shotgun, but a very sophisticated discovery tool.

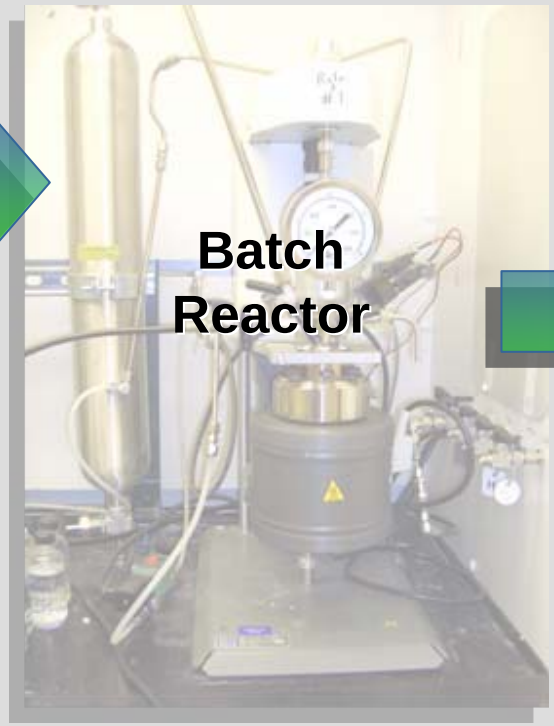
- High speed screening/optimization process
  - tens or hundreds of experiments in parallel
  - time is drastically reduced
- In catalysis research…
  - the number of possible combinations is virtually infinite
  - It is not possible to try all of them
- In performing numerous experiments, the need remains for
  - intelligent design of experiments
  - Informatic tools for analyzing experiments

Integration of Combinatorial Discovery

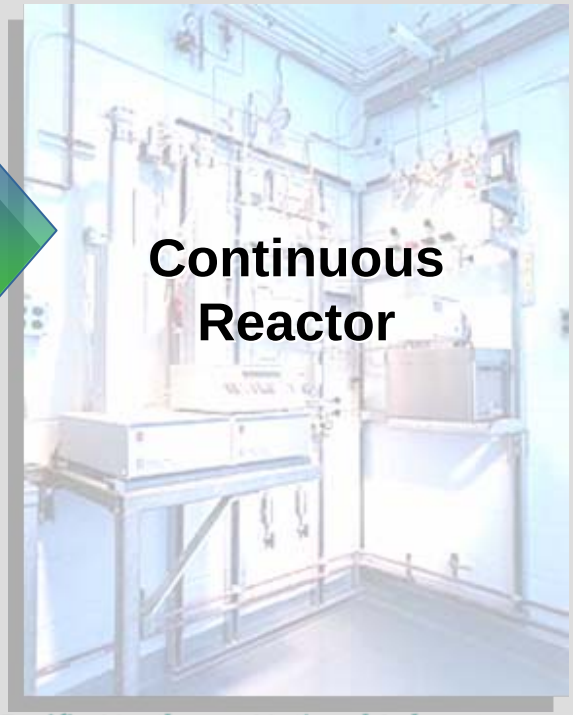
Experimental Rational

Discovery*

Verification



Scale Up



*System provided by Symyx®
With PNNL Design Input

PNNL Offers Unique Capabilities

- Condensed phase catalysis
  - Reaction pathway selection – hydrogenation, hydrogenolysis, dehydration, oxidation
  - Catalyst synthesis & characterization
  - Process definition – continuous vs. batch, high conversion efficiency, high product selectivity
- Bio-Process development
  - “Discovery” – screening, gene selection, etc.
  - Molecular biology applied to fermentation process development
  - Bio-process laboratory with protein/DNA analytical and purification systems
  - Production of unique enzymes as biocatalysts
- Complete process and product characterization

Novel Bio-Processes: Developing & Exploiting New Organisms

- Battelle's objective is to exploit fungi to create new biological processes that:
  - Support production of new products
  - Utilize single, highly-effective production host to selectively produce multiple end products
  - Offer reduced costs by
    - operating at very low pH
    - using lower-cost media
    - achieving very high yield and fermentation rates
- Battelle research focuses on two primary tasks
  - Reducing the time and cost to control and manipulate a new organism
  - Reduce the time and cost of defining a new process