

*Application of Combinatorial Methods to
Heterogeneous Catalysis*

Jennifer Holmgren
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Topics



- **Industry background**
- **Innovation, competitiveness, and the chemical industry**
- **Expected impact of combinatorial chemistry**
- **Role of ATP**

Recent Prediction

1981 “640K ought to be enough computer memory for anyone”

- Bill Gates

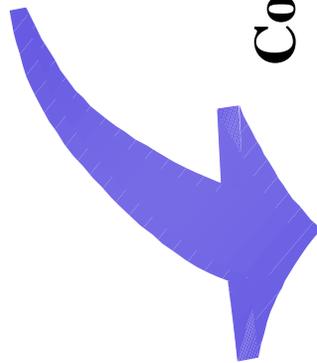
Chemical Industry Background

- **Technology differentiation has been a source of significant competitive advantage.**
- **Many companies have undergone radical changes in structure, reengineering to raise productivity and reduce cycle time.**

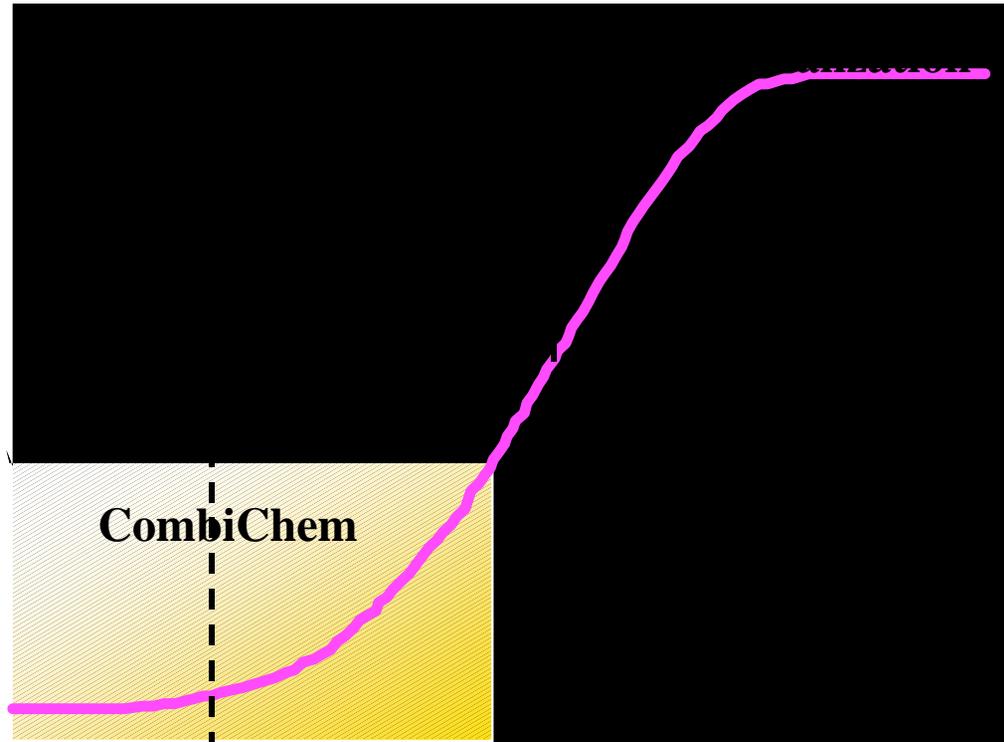
Combinatorial Chemistry

Technology Delivery

*Affects
Front End of
R&D Process*

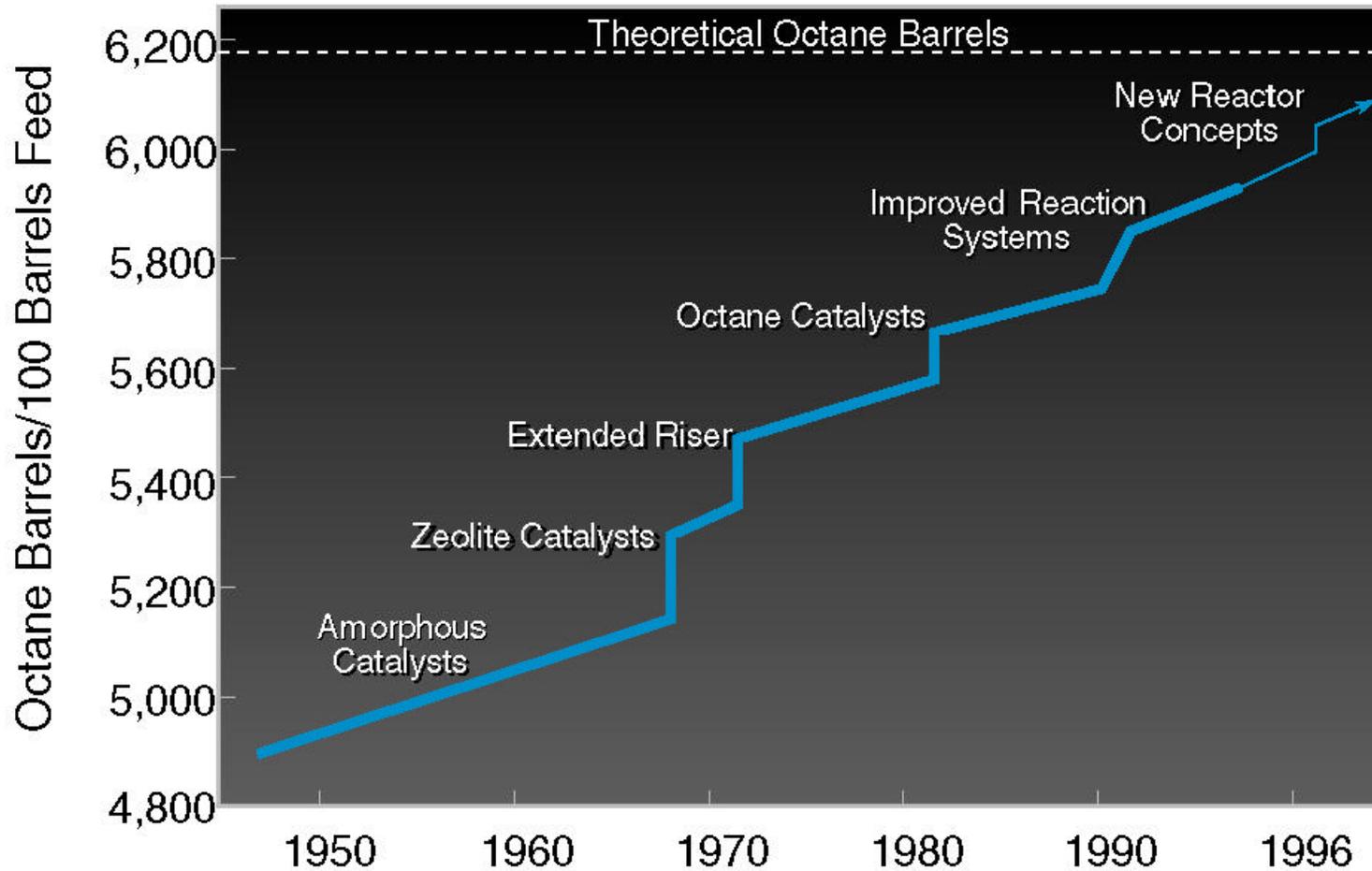


Cost (\$)



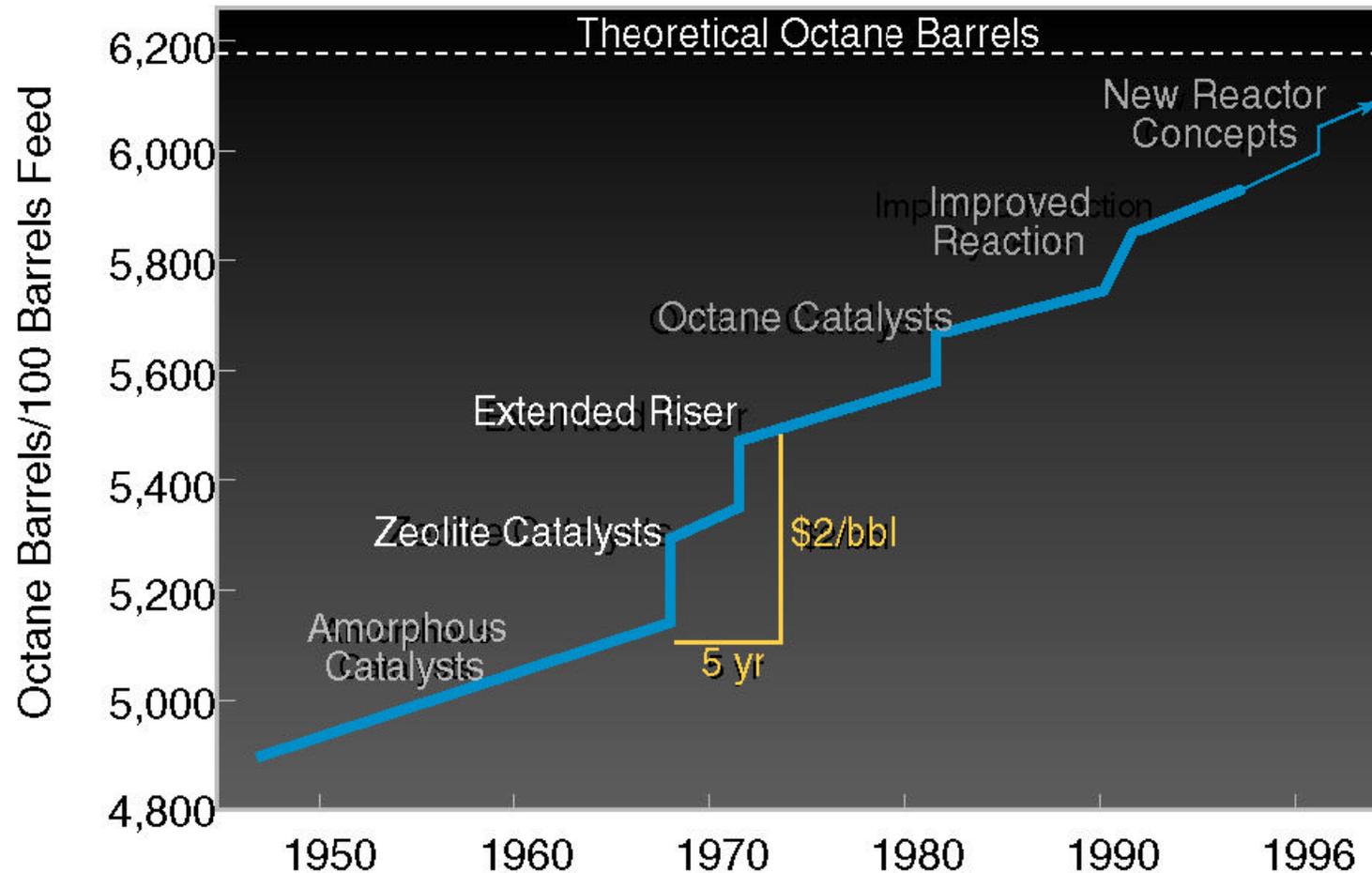
Time (yrs)

Octane Barrel Capacity of FCC



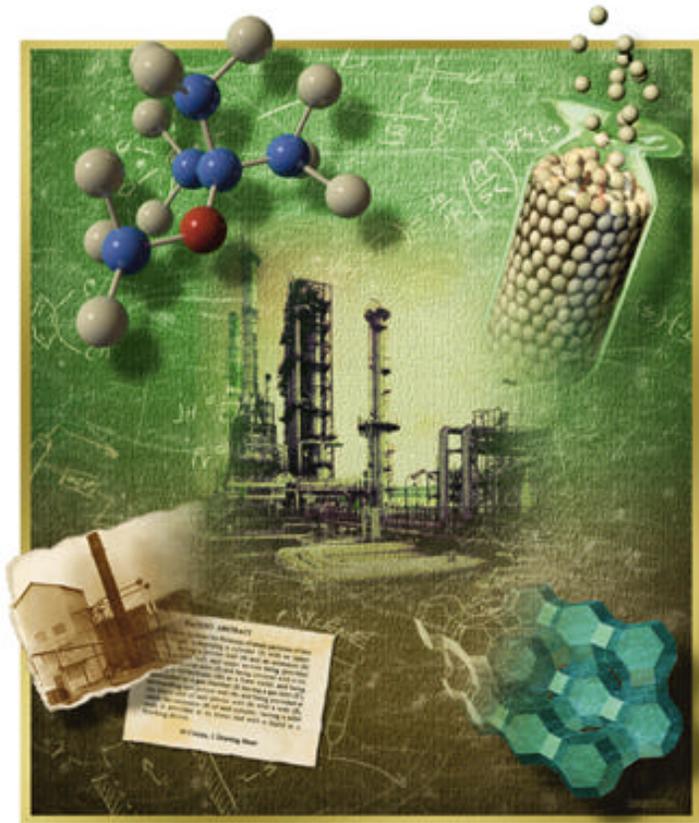
Continuous Improvement is Necessary

Octane Barrel Capacity of FCC



Technology Differentiation and Cycle Time are the Key

Rate of Innovation in A Mature Industry



- **Slowing down as the chemical industry matures.**
- **Tougher, but more important in today's global economy.**

Innovation required to enable growth and maintain competitiveness.

Global Realities



- **Products, capital, and technology moving freely**
- **Standardized specifications**
- **No more niches**
- **Good ideas know no nationality**

More competitive every day!

Impact of Catalyst Innovation



- **Increase return on investment**
 - ❖ **Capital cost**
 - ❖ **Product quality**
 - ❖ **Yields**
 - ❖ **Manufacturability**
 - ❖ **On-stream factor**
 - ❖ **Energy consumption**
 - ❖ **Asset management**
- **Meet changing market demands**
- **Permit feedstock flexibility**
- **Increase focus on environmental stewardship**

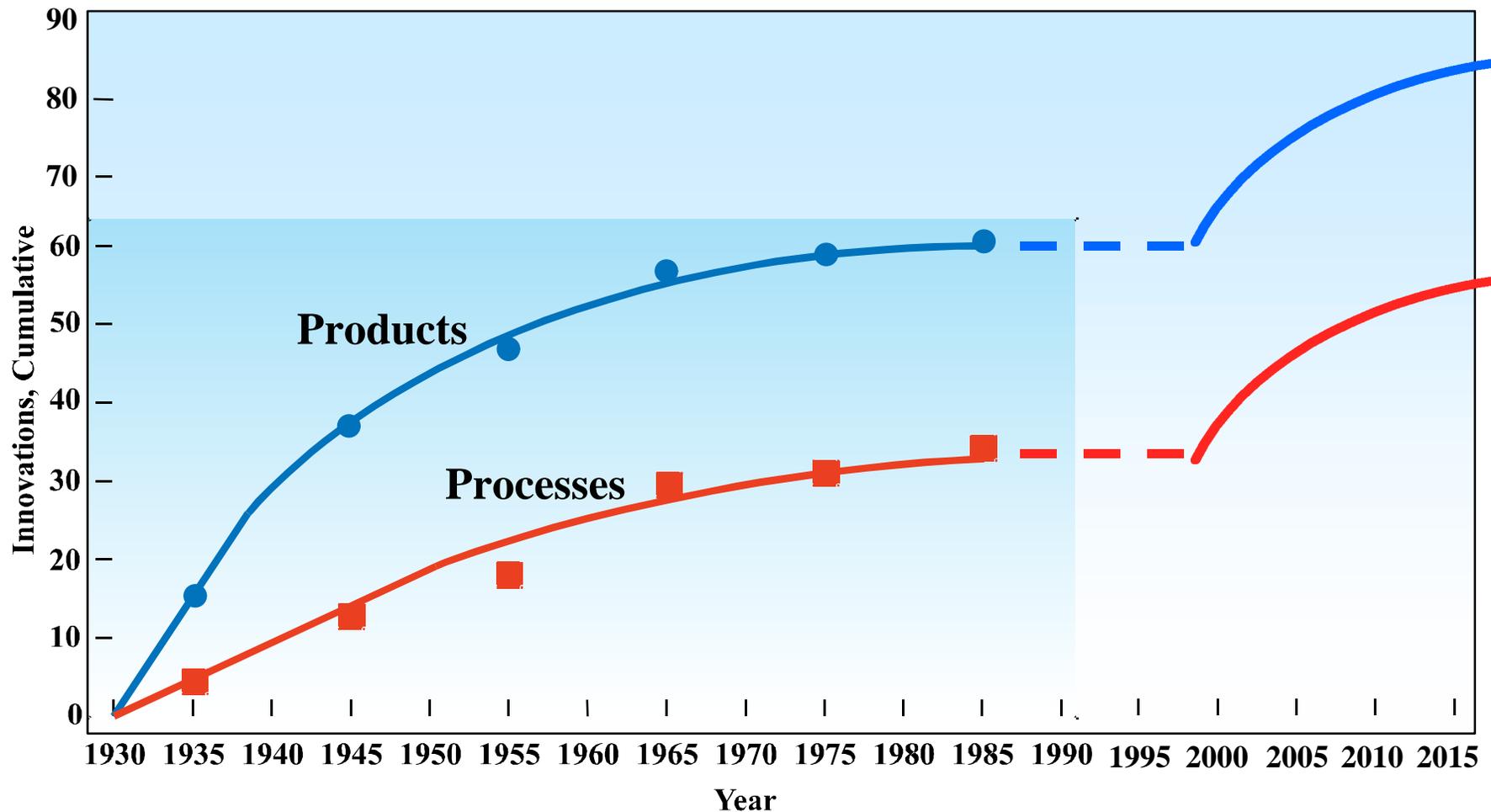
Impact on the Technology Delivery Process

- **Discovery of novel materials, catalysts and adsorbents**
 - ❖ **Increased probability of breakthrough**
 - ❖ **Increase understanding compositional-property relationship**

- **Catalytic process optimization**
 - ❖ **Improve understanding of process variables**
 - ❖ **Better quality data (control)**
 - ❖ **Better models**

- **Manufacturing**
 - ❖ **Develop more robust manufacturing recipes**
 - ❖ **Enhanced understanding of the impact of synthesis variables on performance**

Changing the Shape of the Curve



Key Enabler: Novel Tools

Combinatorial Chemistry

- **Enabler for the chemical industry**
 - ❖ **Increase rate of innovation**
 - ❖ **Reduce cycle time**
- **Capability will be portable**

Must-have technology.

Expanding the Horizons of Catalysis R&D

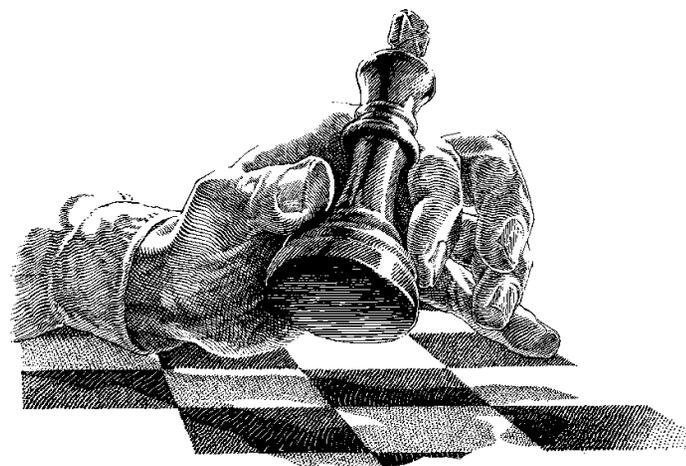
Doubling on a Chess Board

1 cent on white squares only
doubles in value 31 times
Totals \$21.5 Million

1 cent on black & white squares
Totals \$92 Million Billion

Combinations of Elements

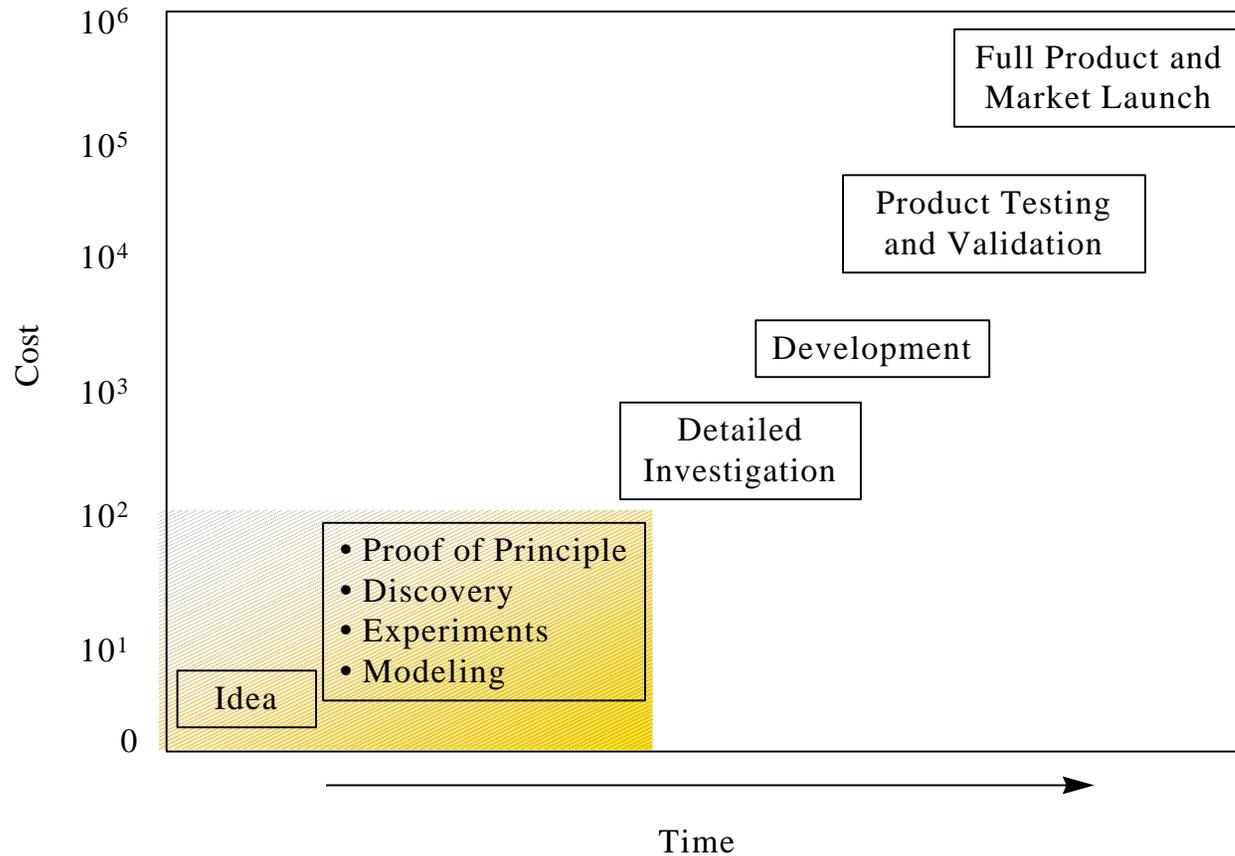
4 at a time = 300 Billion



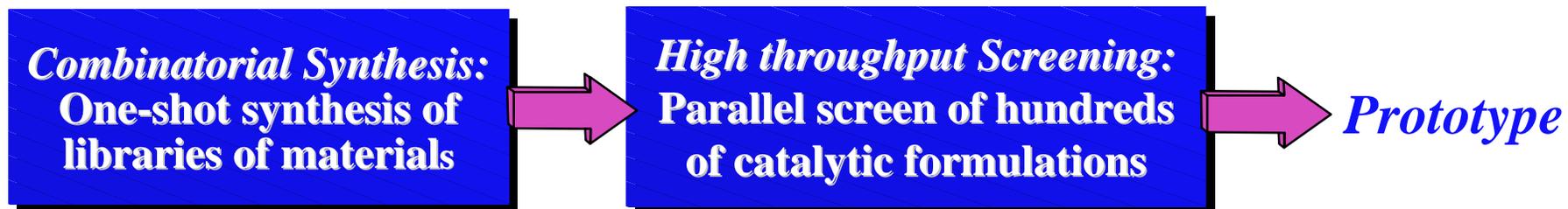
Combichem Enables Extension of Catalysis Beyond Binaries

Paul Romer's Updated Legend

Cost of Technology Delivery

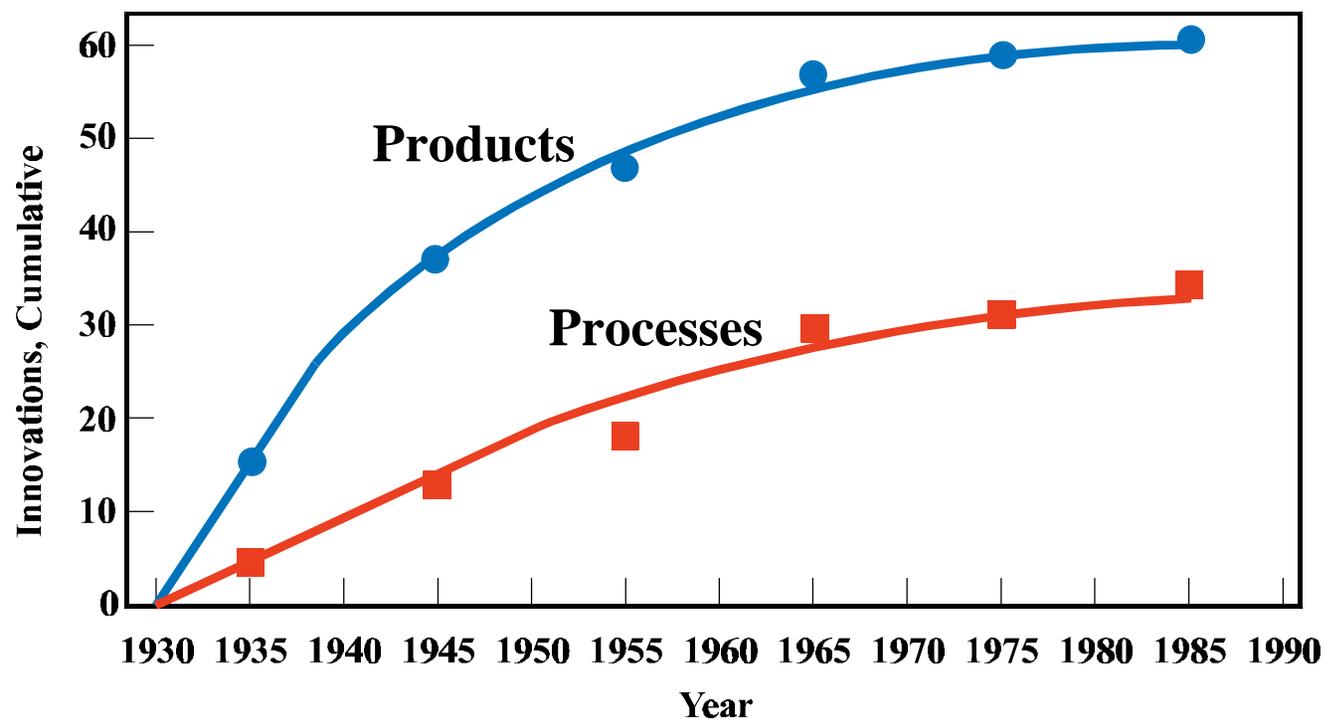


Technical Goals



Select to 2-3 Candidates

Slowing Innovations in the Chemical Industry



Product and Process Innovations from 1930 to 1985 Are Shown

Source: Chemtech 1995, 25(6), 6.