

# Noyori Reduction (Asymmetric Hydrogenation)

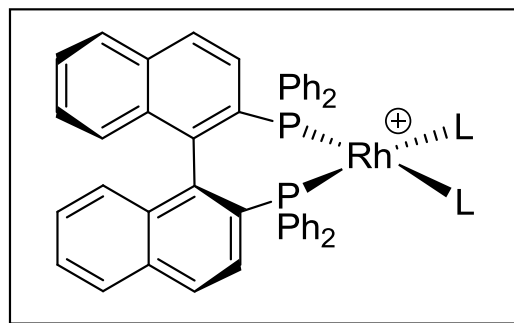
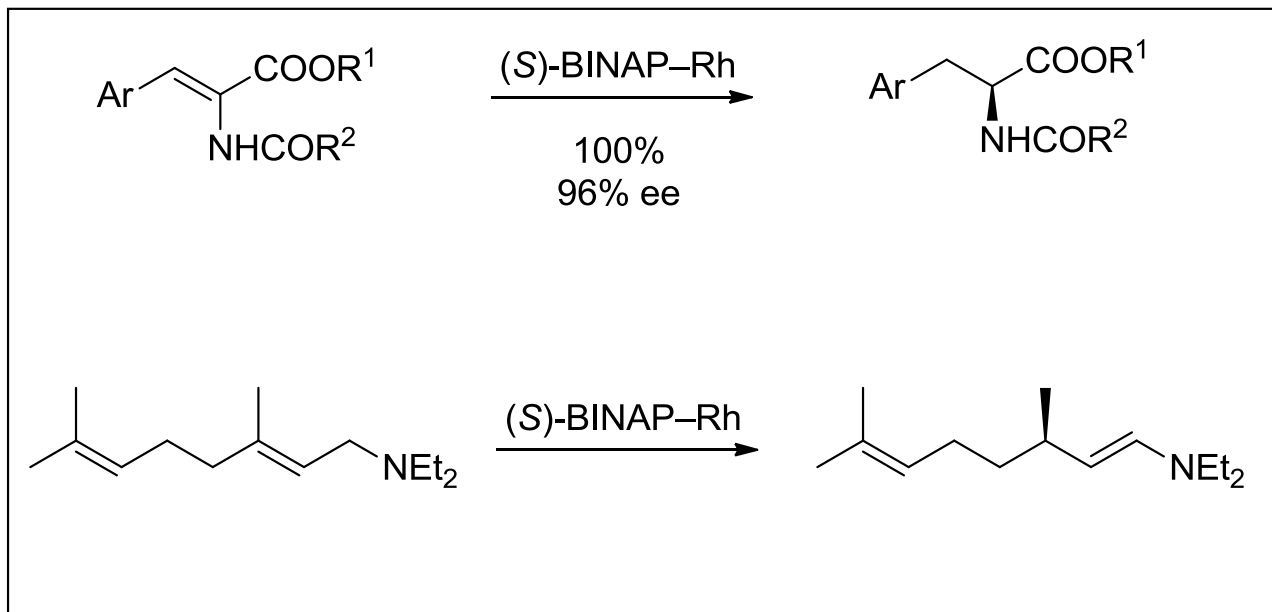
Daniel Tao  
Overman Group Meeting  
4/30/12

# Ryoji Noyori



- Born in 1938 in Kobe, Japan
- Received B.S. and Ph.D. from Kyoto University
- Postdoctoral work with E.J. Corey before returning to Nagoya University in Japan
- Shared the 2001 Nobel Prize with K.B. Sharpless and W.S. Knowles

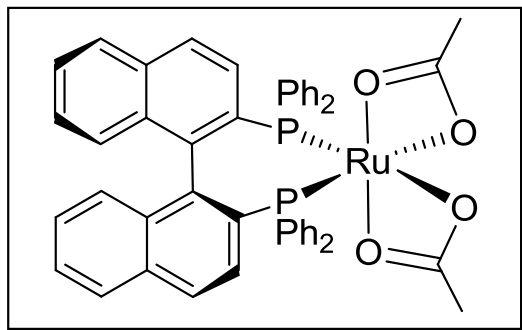
# Initial Work in the 1980's



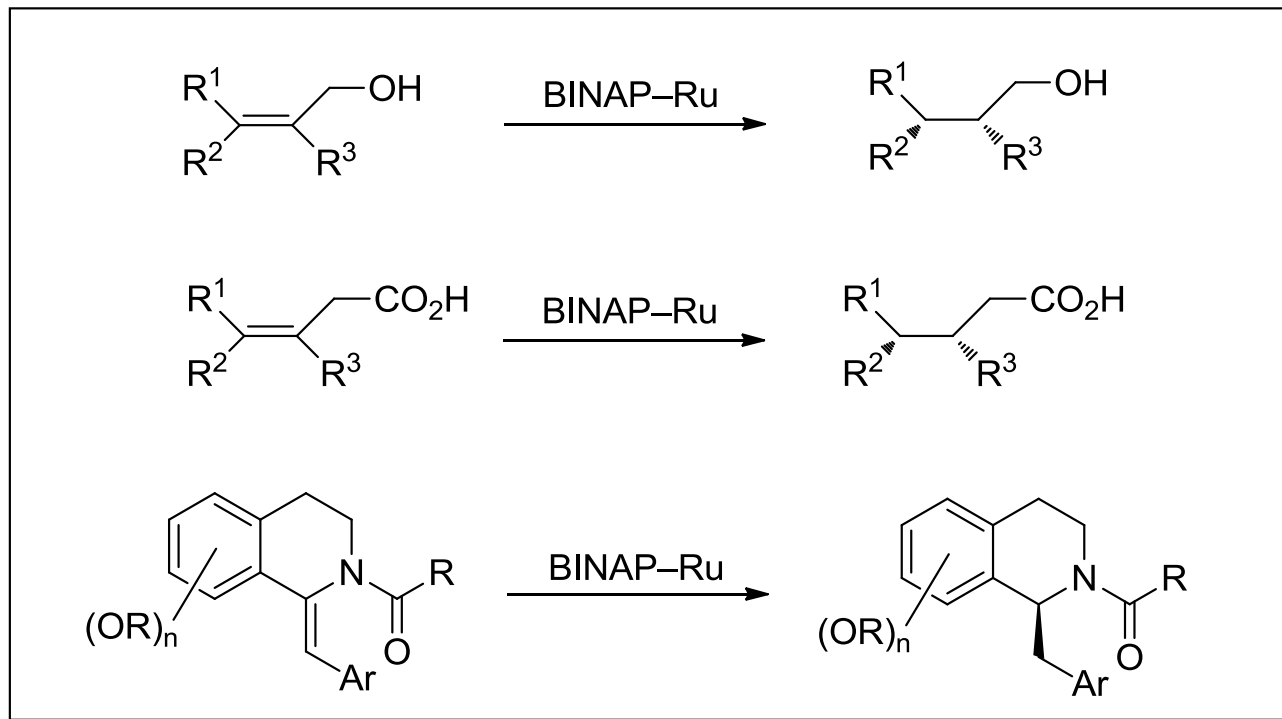
Noyori, R. *et al.* *J. Am. Chem. Soc.* **1980**, *102*, 7932–7934.

Noyori, R. *et al.* *J. Am. Chem. Soc.* **1984**, *106*, 5208–5217.

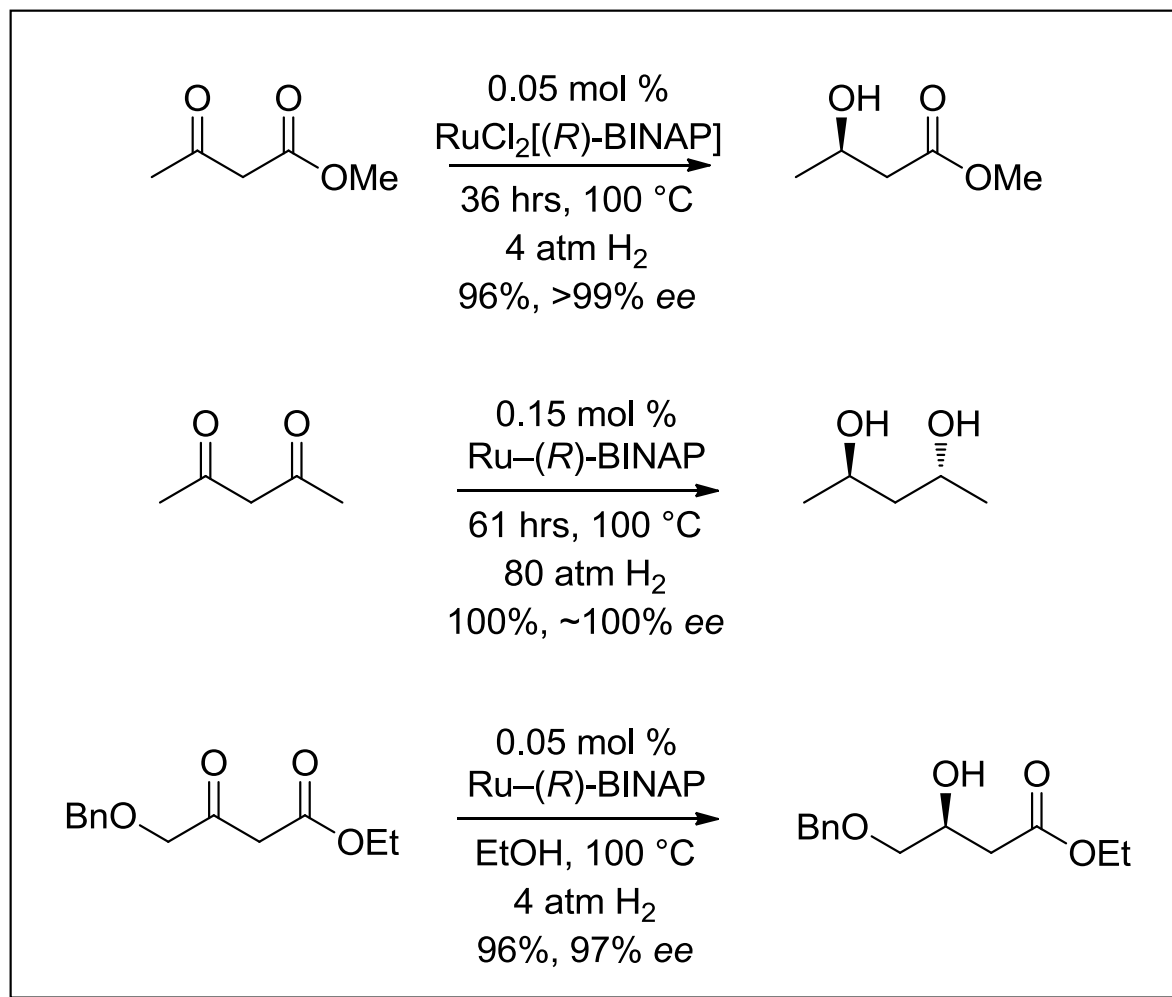
# Switching to Ru(II) Catalyst



- 23 °C for 2–3 days
- 4 atm H<sub>2</sub>
- Yields almost quantitative
- ee's >95%



# Asymmetric Reduction of Ketones

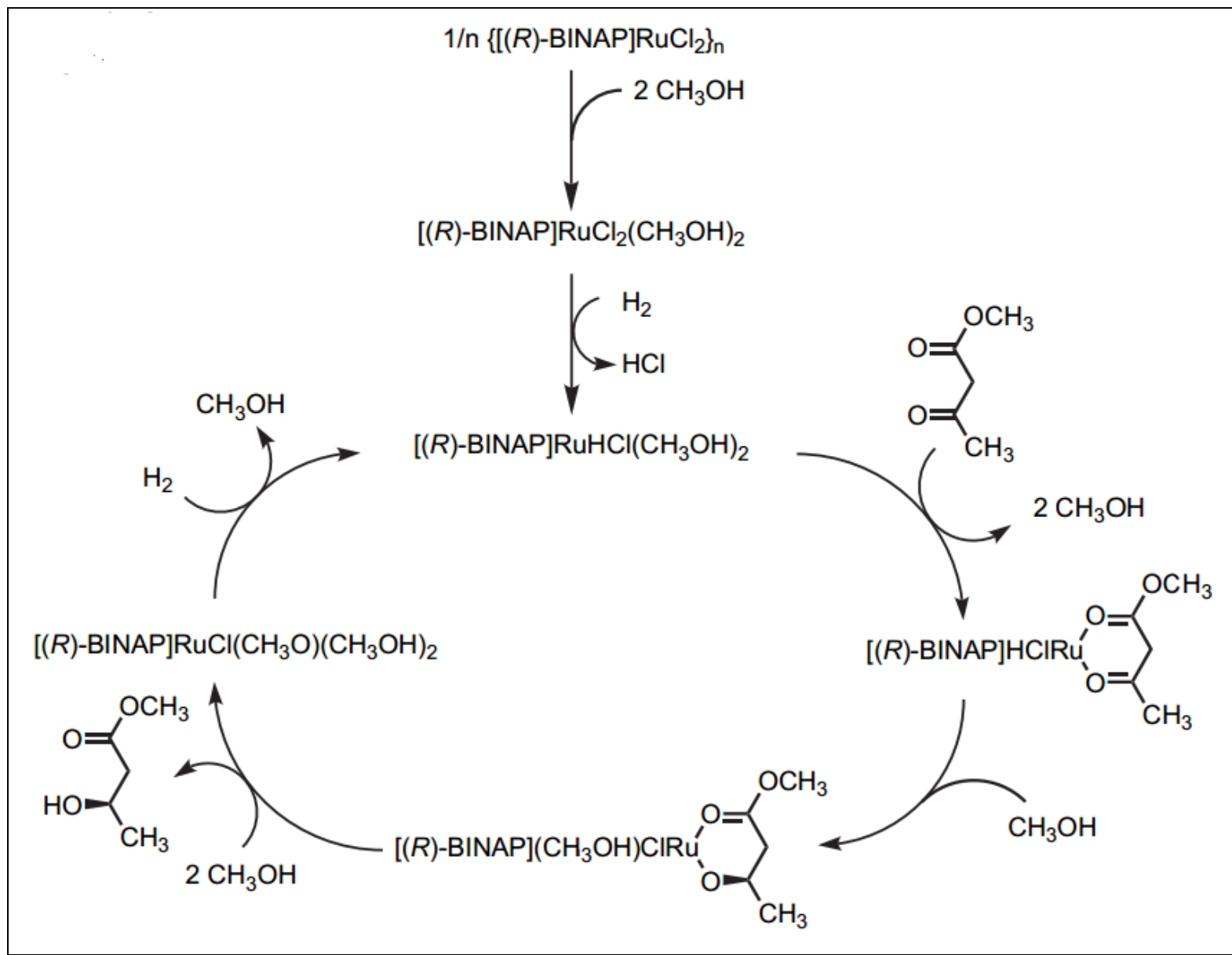


Noyori, R. *et al.* *J. Am. Chem. Soc.* **1987**, *109*, 5856–5858.

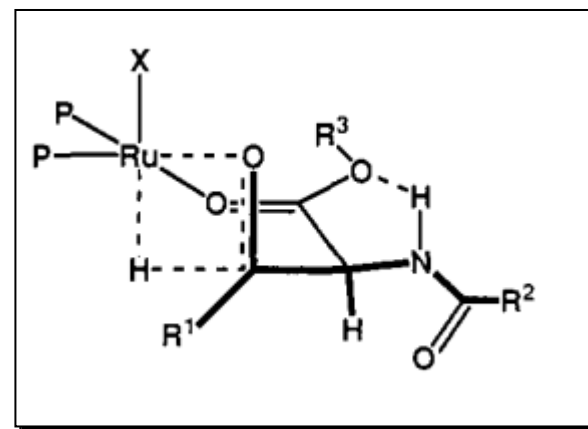
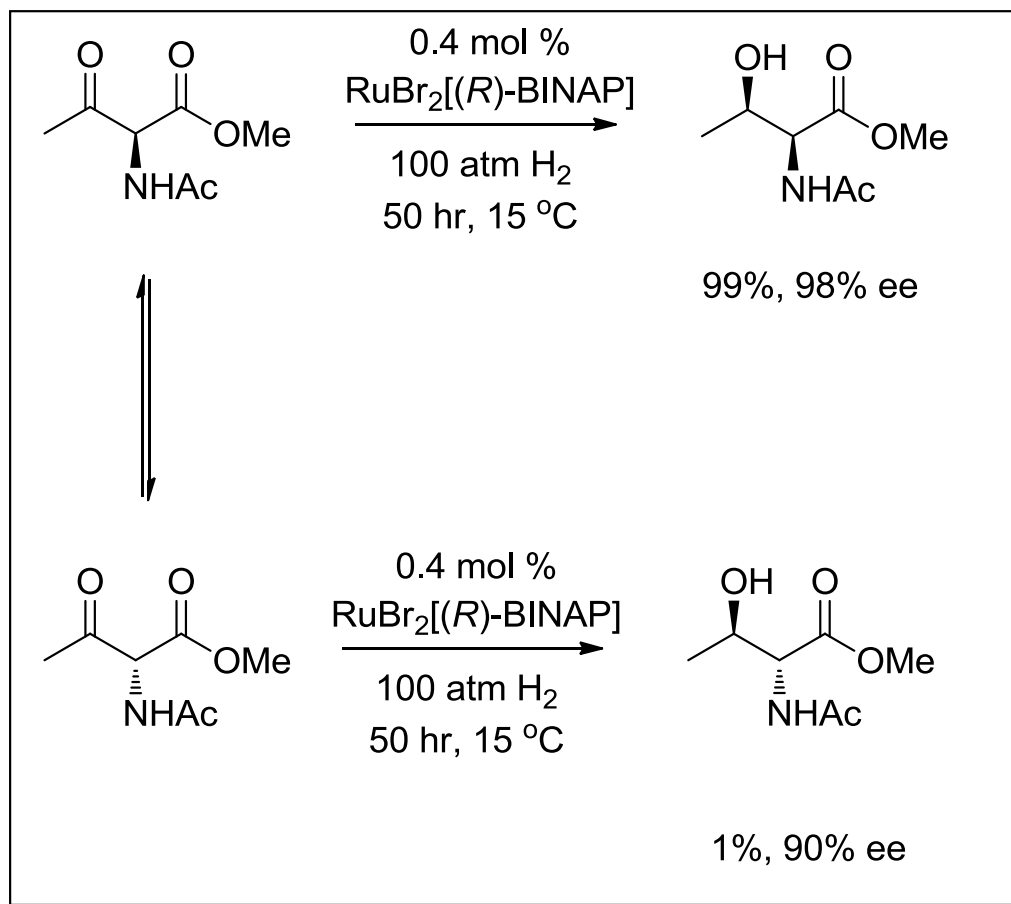
Noyori, R. *et al.* *J. Am. Chem. Soc.* **1988**, *110*, 629–631.

Beck, G.; Jendralla, H.; Kessler, K. *Synthesis* **1995**, 1014–1018.

# Catalytic Cycle

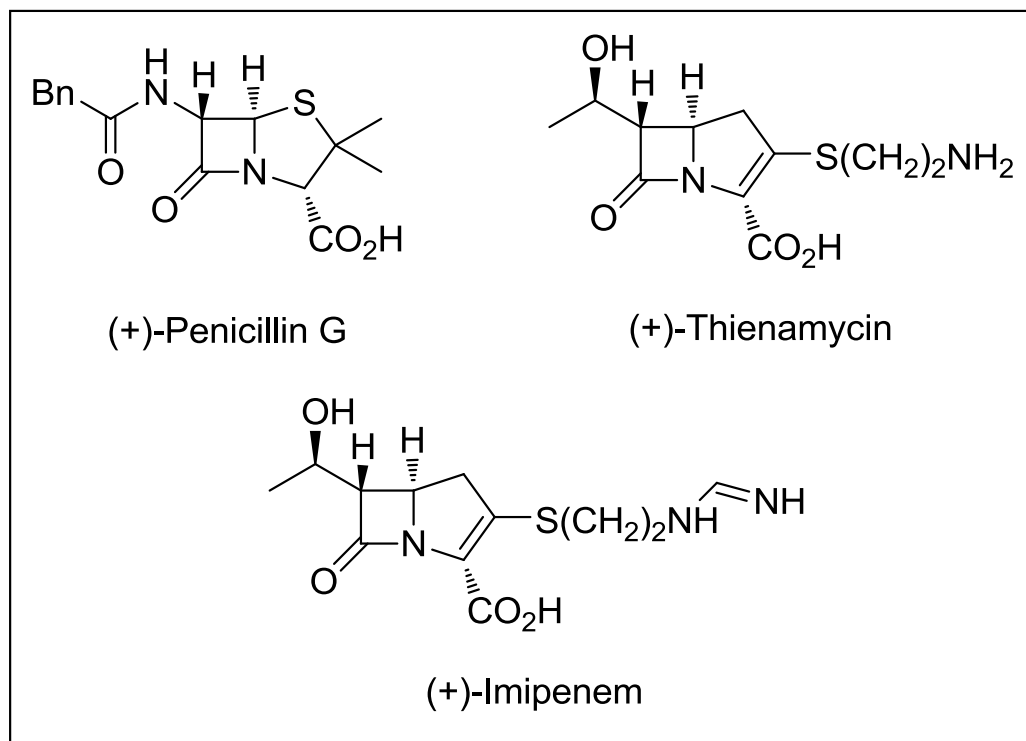
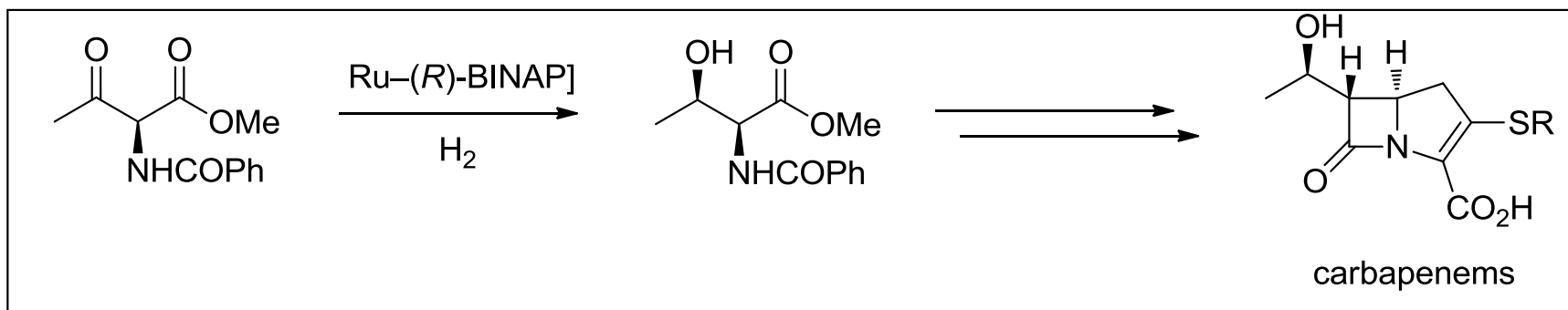


# Application in Dynamic Kinetic Resolution



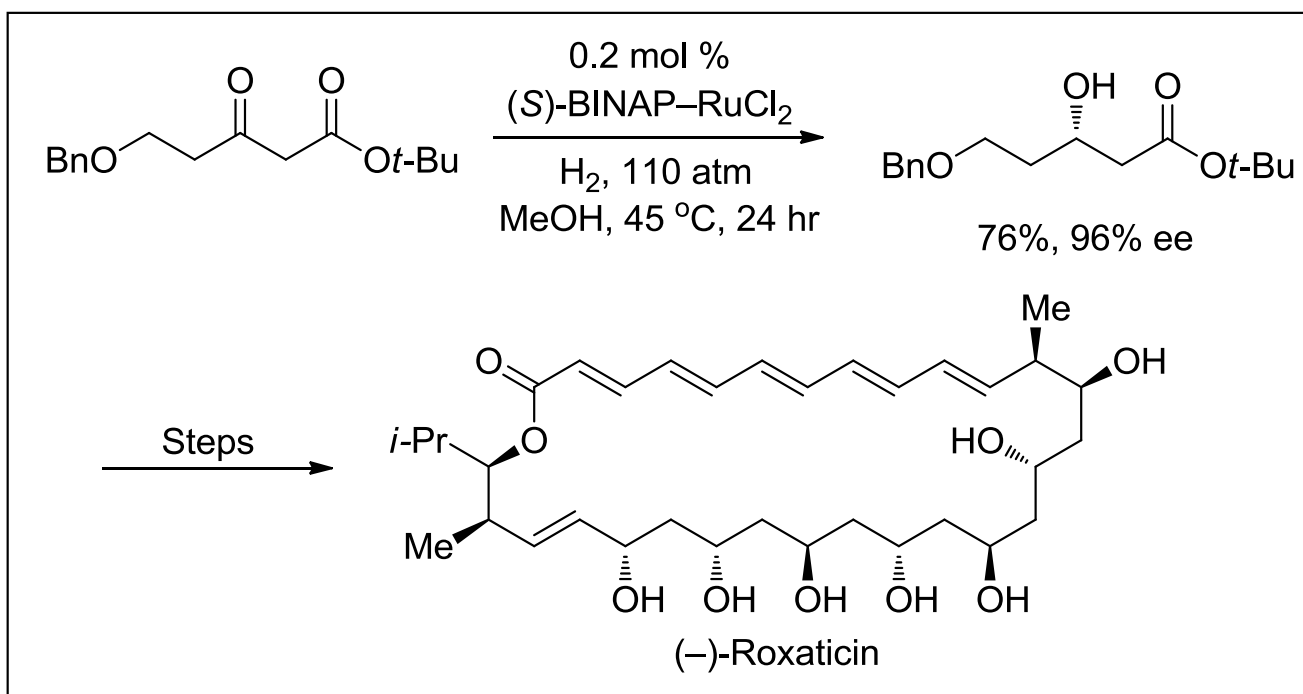
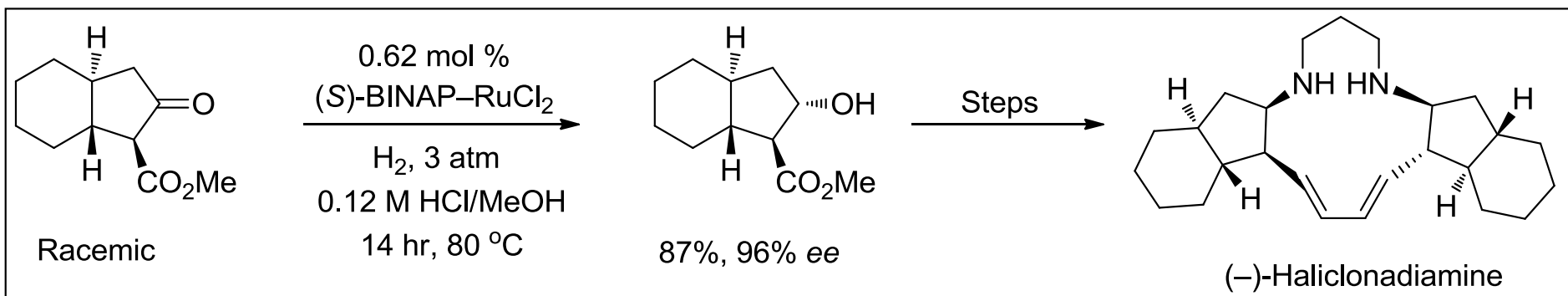
Proposed Transition State

# Dynamic Resolution in Synthesis

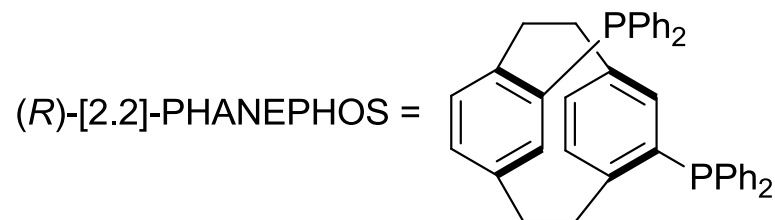
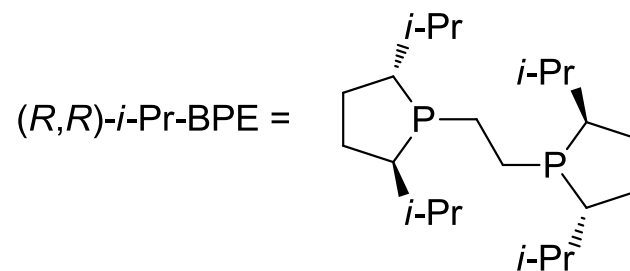
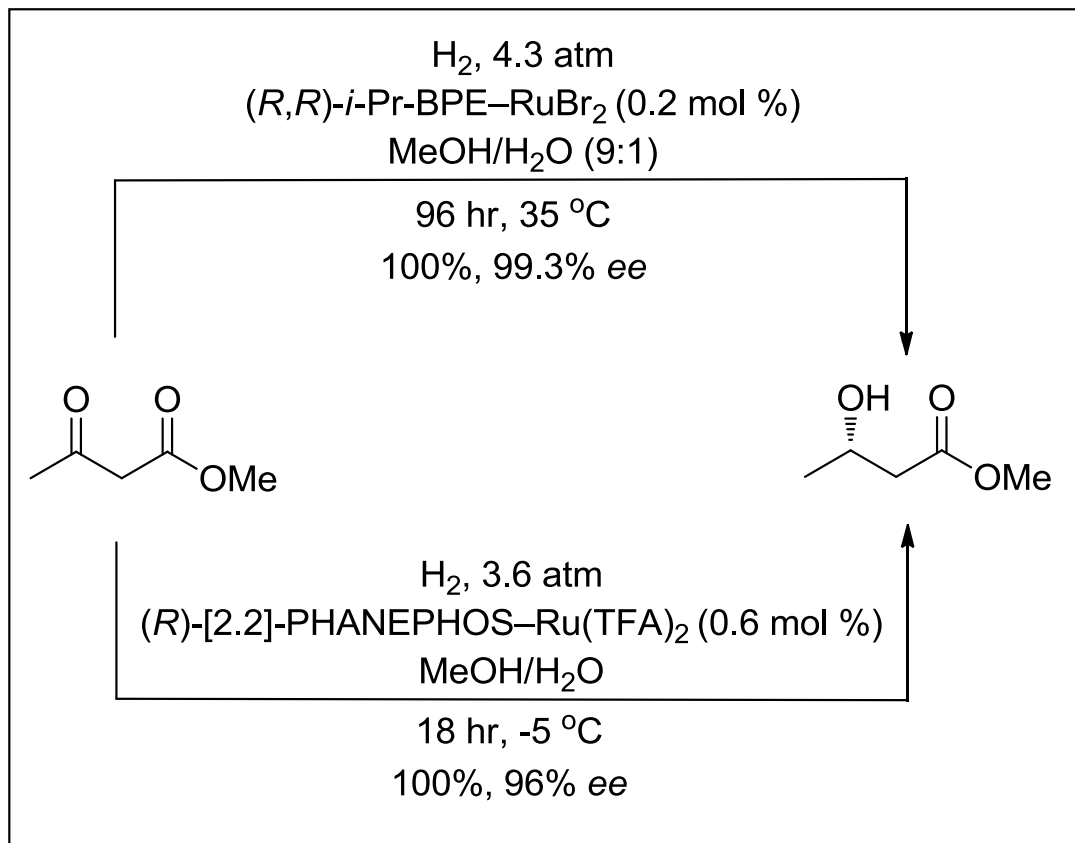




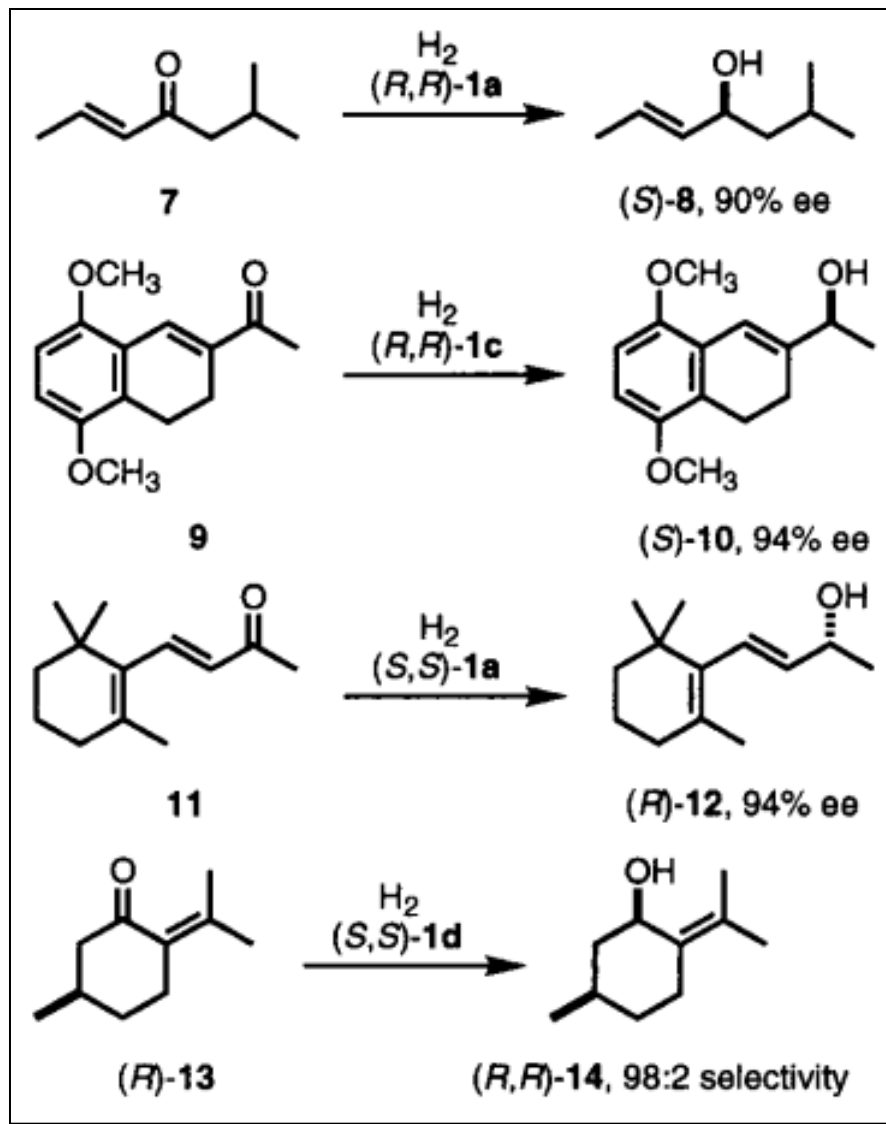
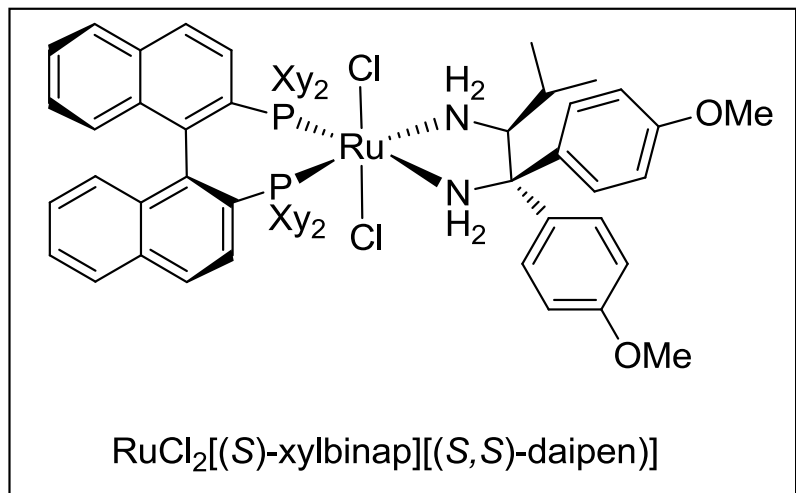
# Noyori Reduction in Synthesis



# Other Ligands for Noyori Reduction

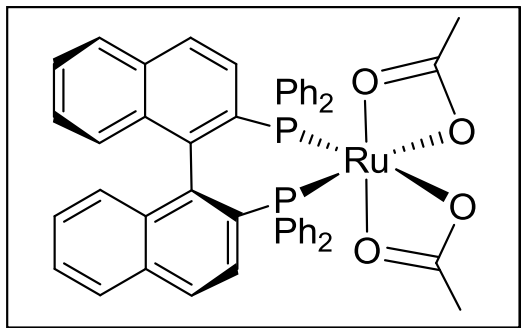


# Other Ligands for Noyori Reduction





# Summary



- The Noyori reduction is asymmetric with typically high enantioselectivity

- Using a Ru-based catalyst with a variety of ligands, the transition state may be 4-centered or 6-centered

- The substrate scope is large, based mainly on proximity to a heteroatom (vinylic to homoallylic)