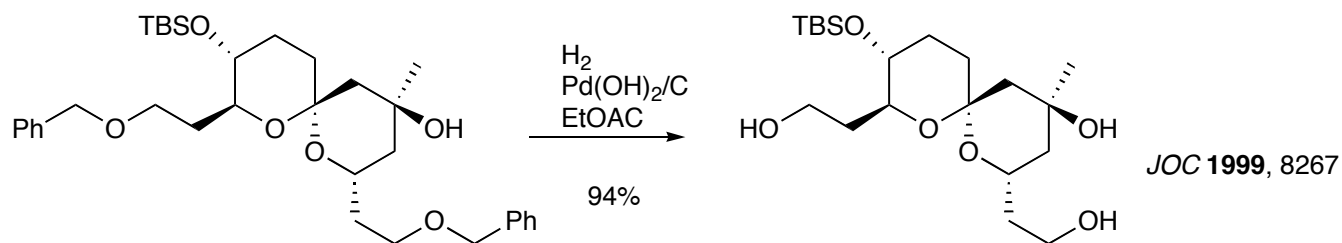
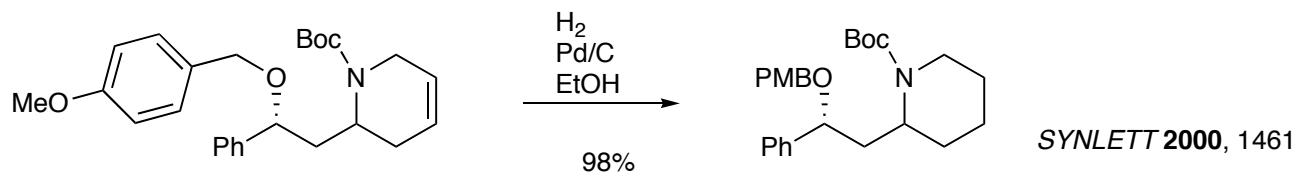
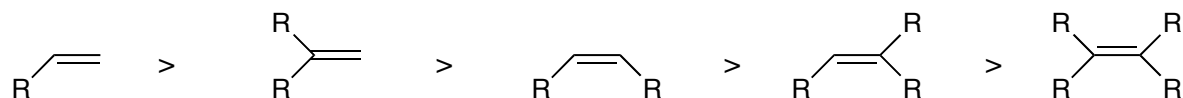


## Examples of Hydrogenation Reactions

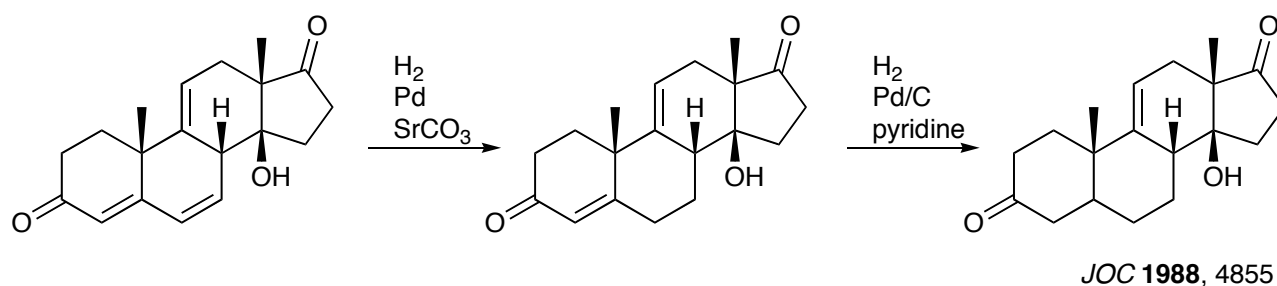


Hydrogenation rate depends on substitution . . . more highly substituted alkenes absorb slowly on the catalyst.

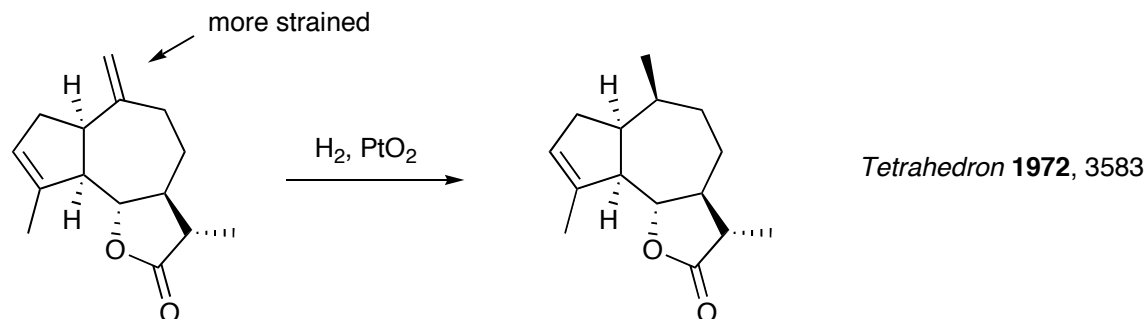
Relative Hydrogenation Rates



Usually depends on catalyst conditions



Strain can make a difference

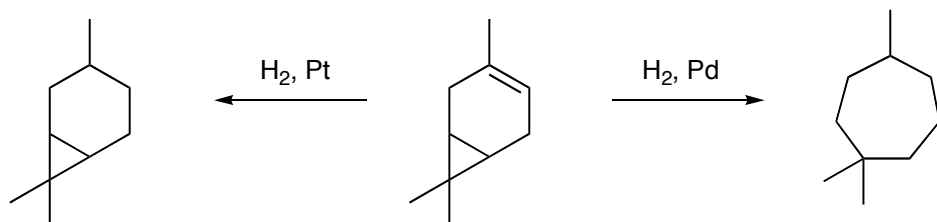




Some catalysts are prone to alkene migration . . . mainly palladium

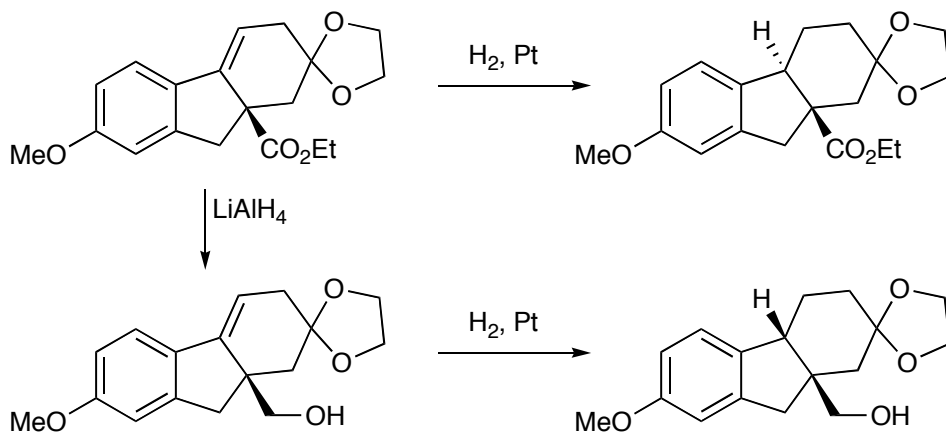
Ability of catalysts to promote alkene migration:

$\text{Pd} > \text{Ni} \gg \text{Rh} = \text{Ru} > \text{Os} = \text{Ir} > \text{Pt}$



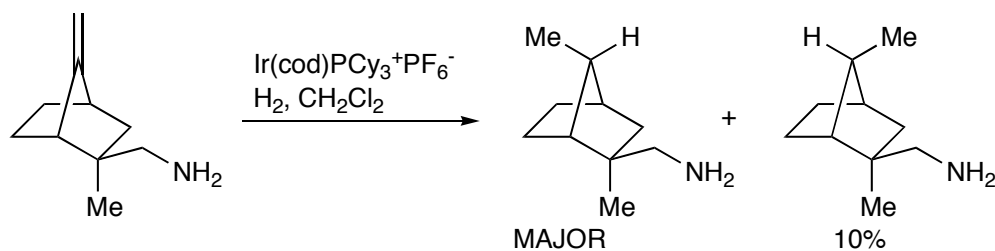
*J. Chem. Soc. C. 1966, 41.*

Groups can coordinate to the catalyst surface



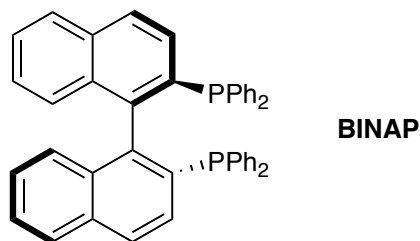
*JACS 1973, 6379*

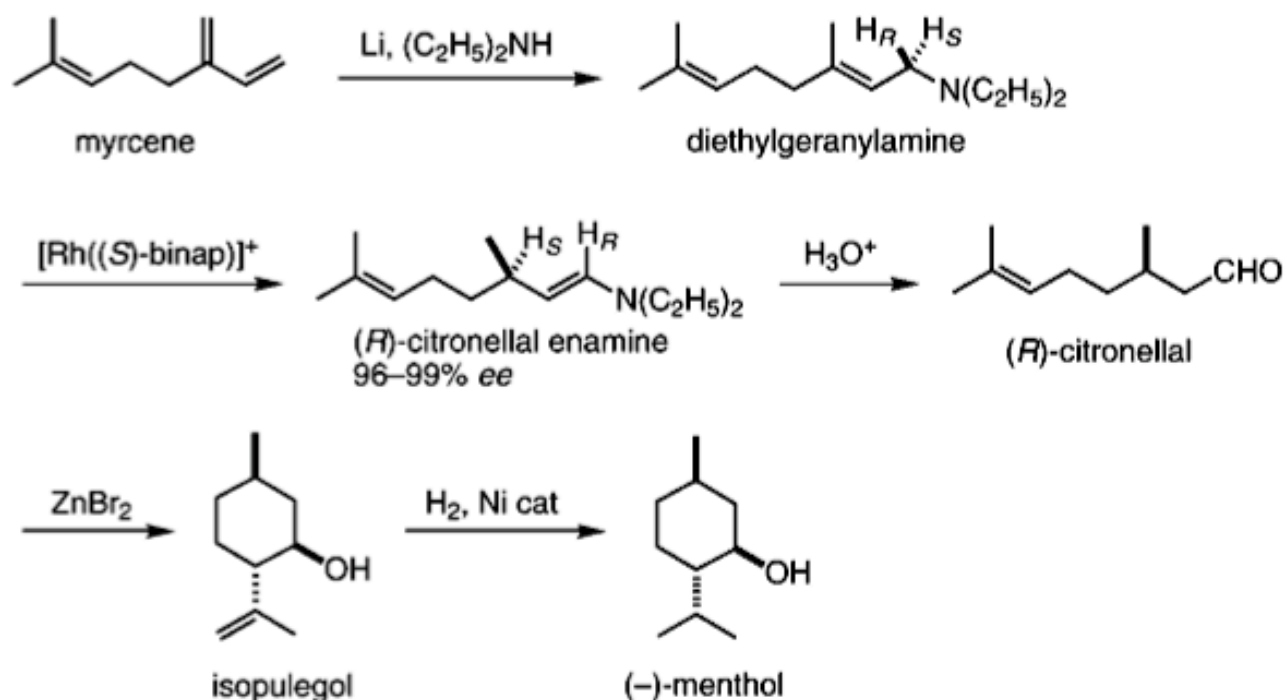
Homogeneous catalysts can coordinate as well. Solvent Dependent (need non-coordinating solvents)



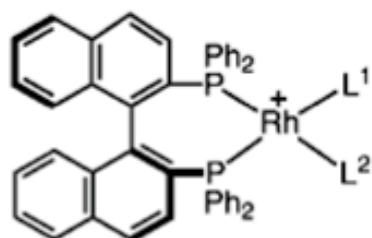
*JOC 1985, 4270*

Asymmetric Hydrogenation Knowles, Chiral Phosphines. 1978 Noyori - Resolve BINAP



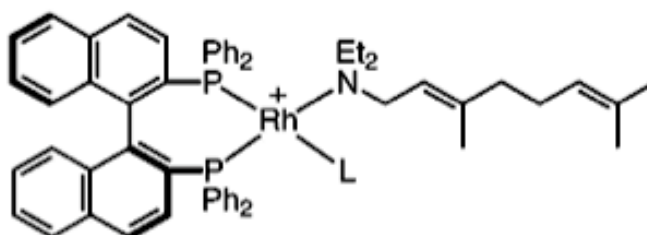


Catalyst (precursor)



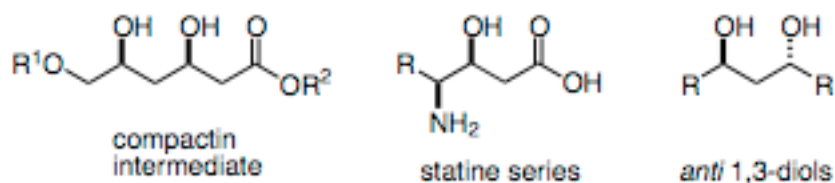
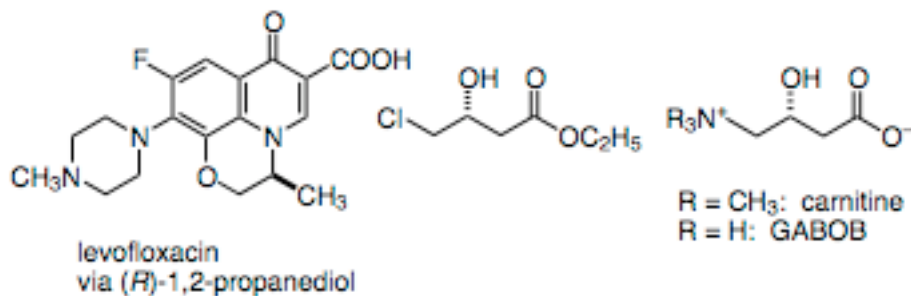
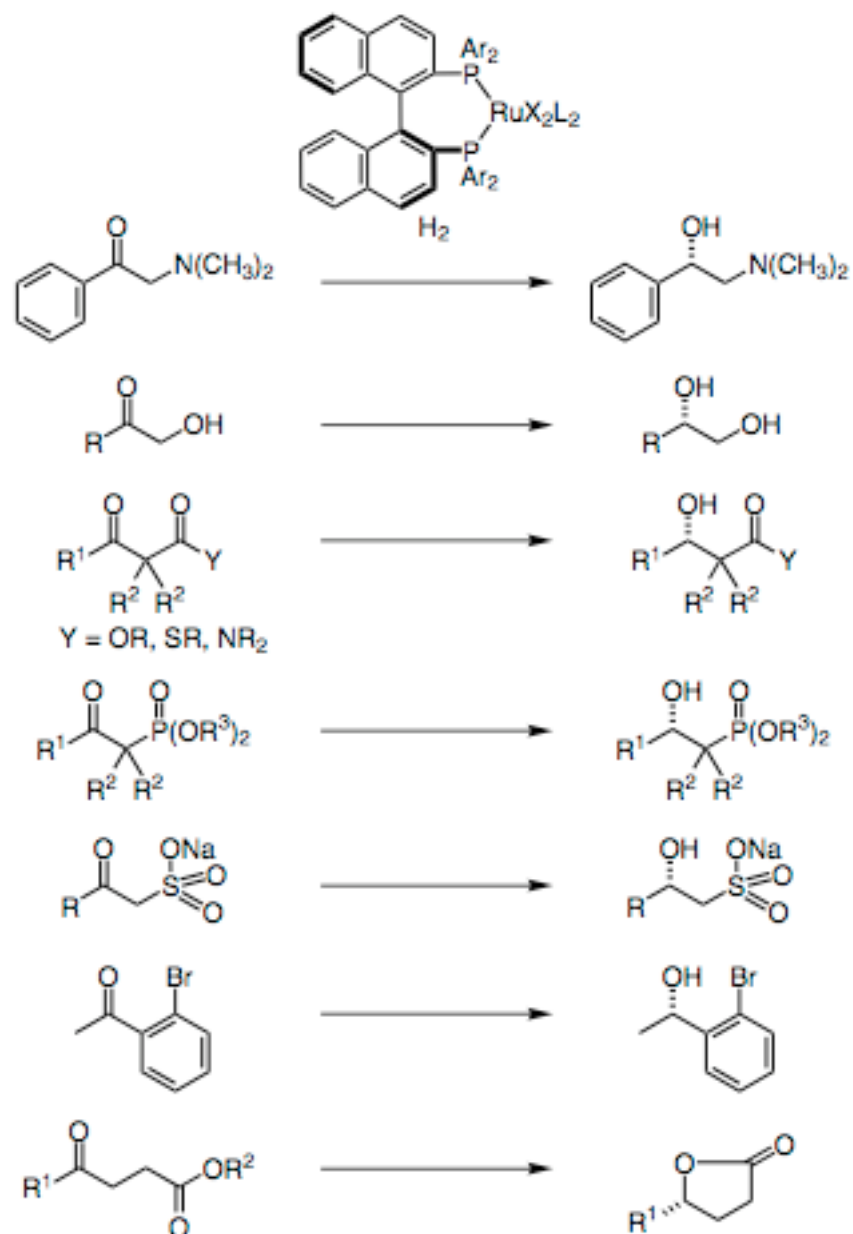
$L^1, L^2 = \text{THF, acetone}$   
 $L^1-L^2 = \text{COD, (S)-BINAP, } \eta^3\text{-enamine}$   
 $L^1 = L^2 = \text{N-coordinated enamine}$

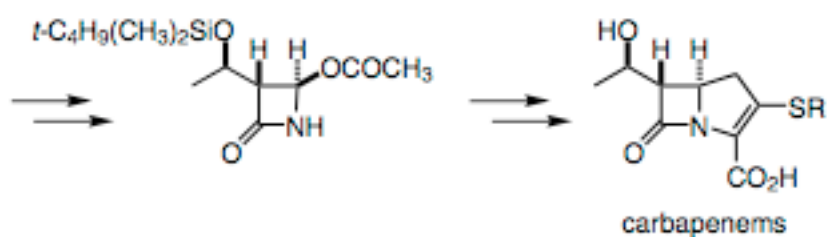
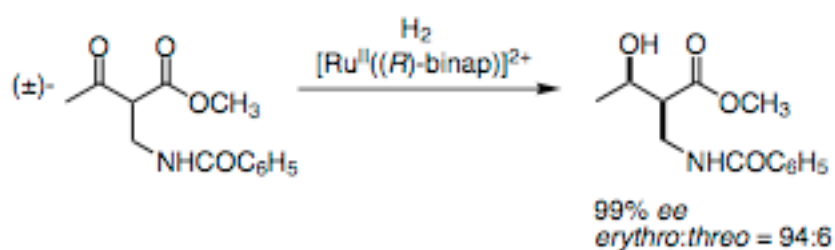
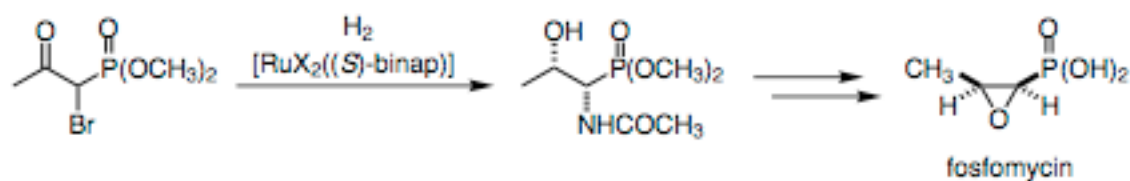
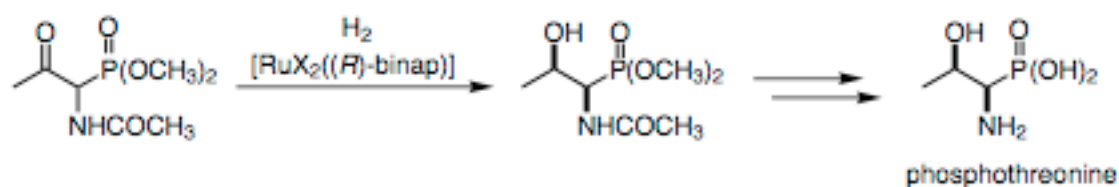
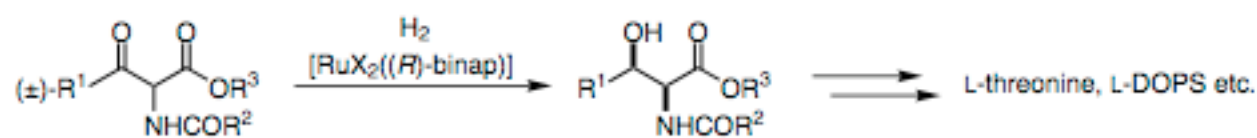
Reactive intermediate in the 1,3-hydrogen shift

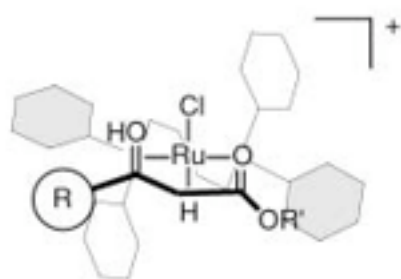
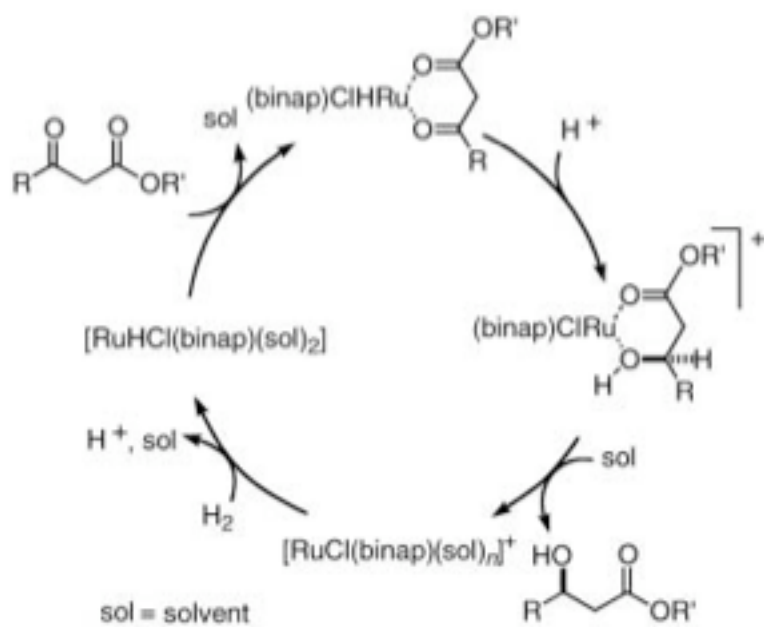


$L = \text{THF, acetone, } \eta^1\text{-enamine}$

Scheme 3. Takasago menthol synthesis. COD = 1,5-cyclooctadiene.



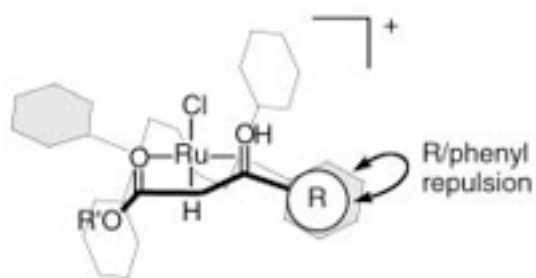




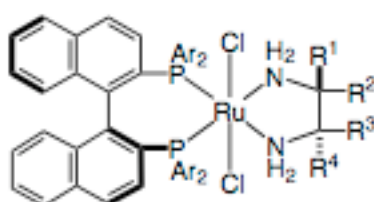
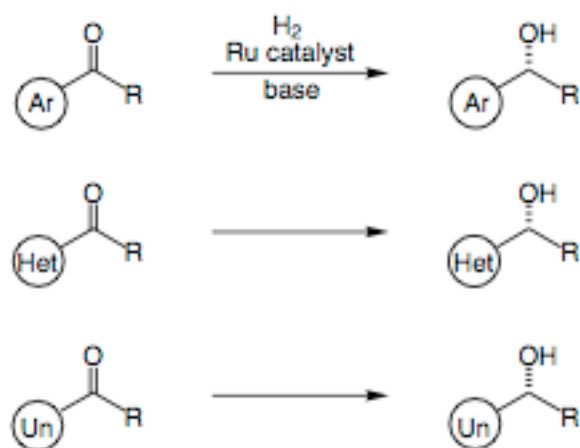
favored TS



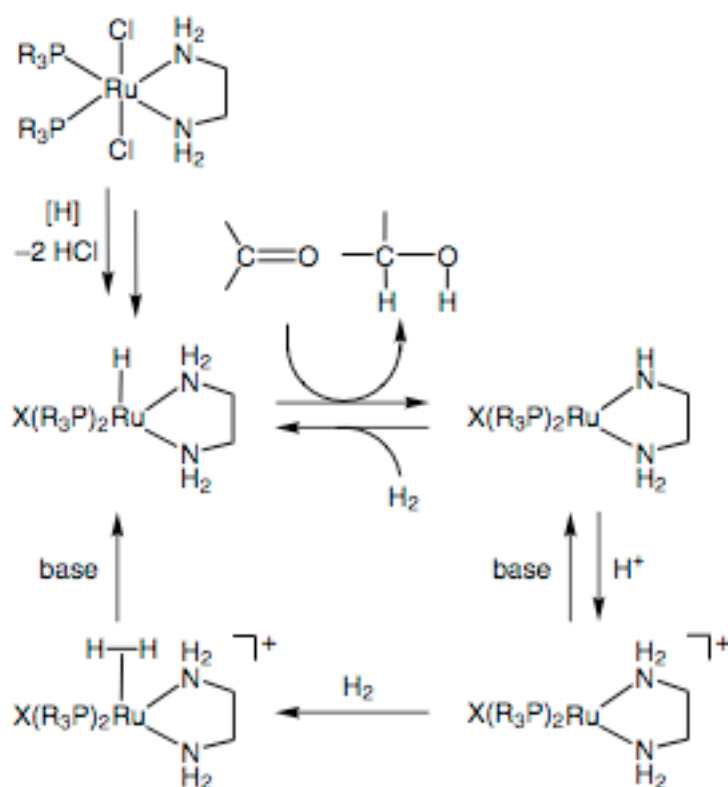
$(R)$ -BINAP

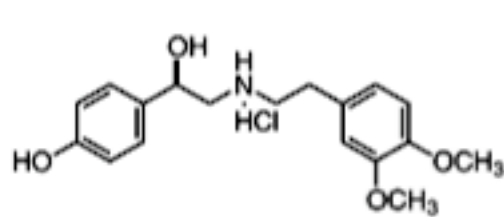


unfavored TS

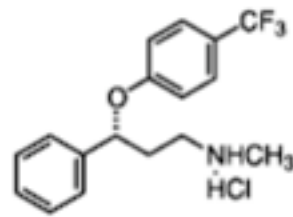


(*S*)-BINAP/(*S*)-diamine-Ru<sup>II</sup> catalyst

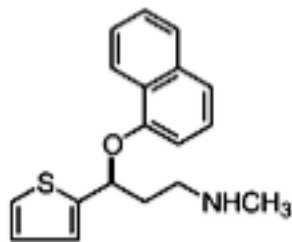




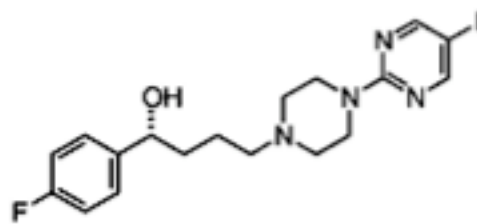
denopamine hydrochloride  
 $\beta_1$ -receptor agonist



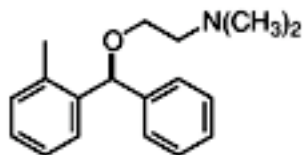
fluoxetine hydrochloride  
antidepressant agent



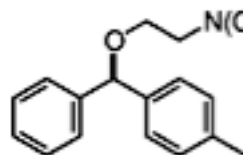
duloxetine  
inhibitor of serotonin and  
norepinephrine



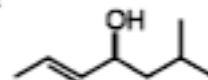
BMS 181100  
antipsychotic agent



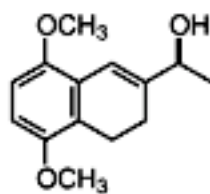
orphenadrine  
antihistaminic and  
anticholinergic agent



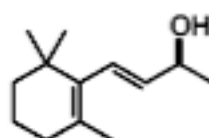
neobenodine  
antihistaminic agent



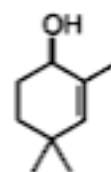
precursor of  
 $\alpha$ -tocopherol



precursor of  
anthracyclins

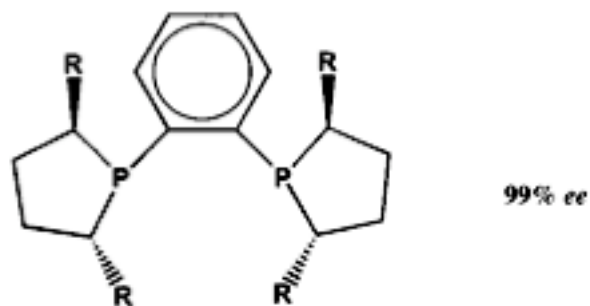
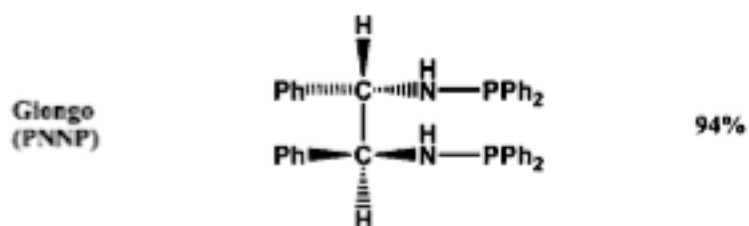
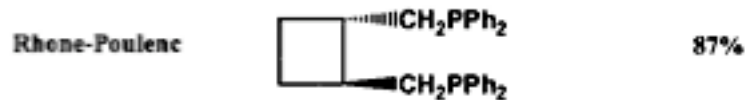
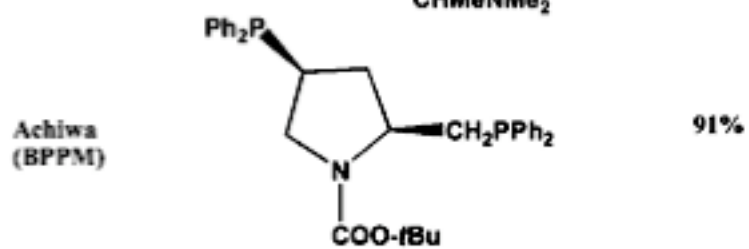
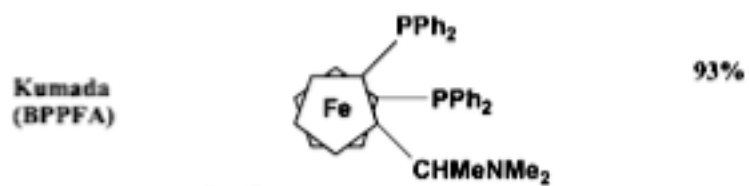
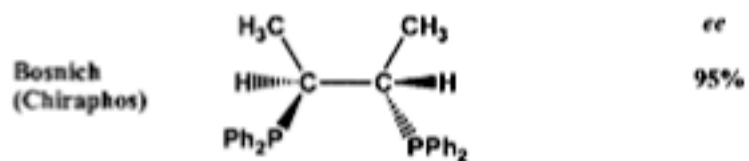


$\beta$ -ionol



precursor of  
 $\alpha$ -damascone





R = Me or Et  
DuPHOS, Burk