Lecture 23

Two Germans and an Englishman

Robert Robinson
1886-1975
Nobel Laureate
1947

Otto Paul Hermann Diels
1876-1954

Kurt Alder
1902-1958

Nobel Laureates
1950

Exam III - Wed April 24

- PAI 3.02
- 7-9 PM
- Covers thru 4/18
- Homework
- Hydrolysis
- Reactions
- Synthesis
- Get an A!!!

Review Session

- Where: Here
- When: Tuesday April 23 at 5PM
- Bring questions from your studies

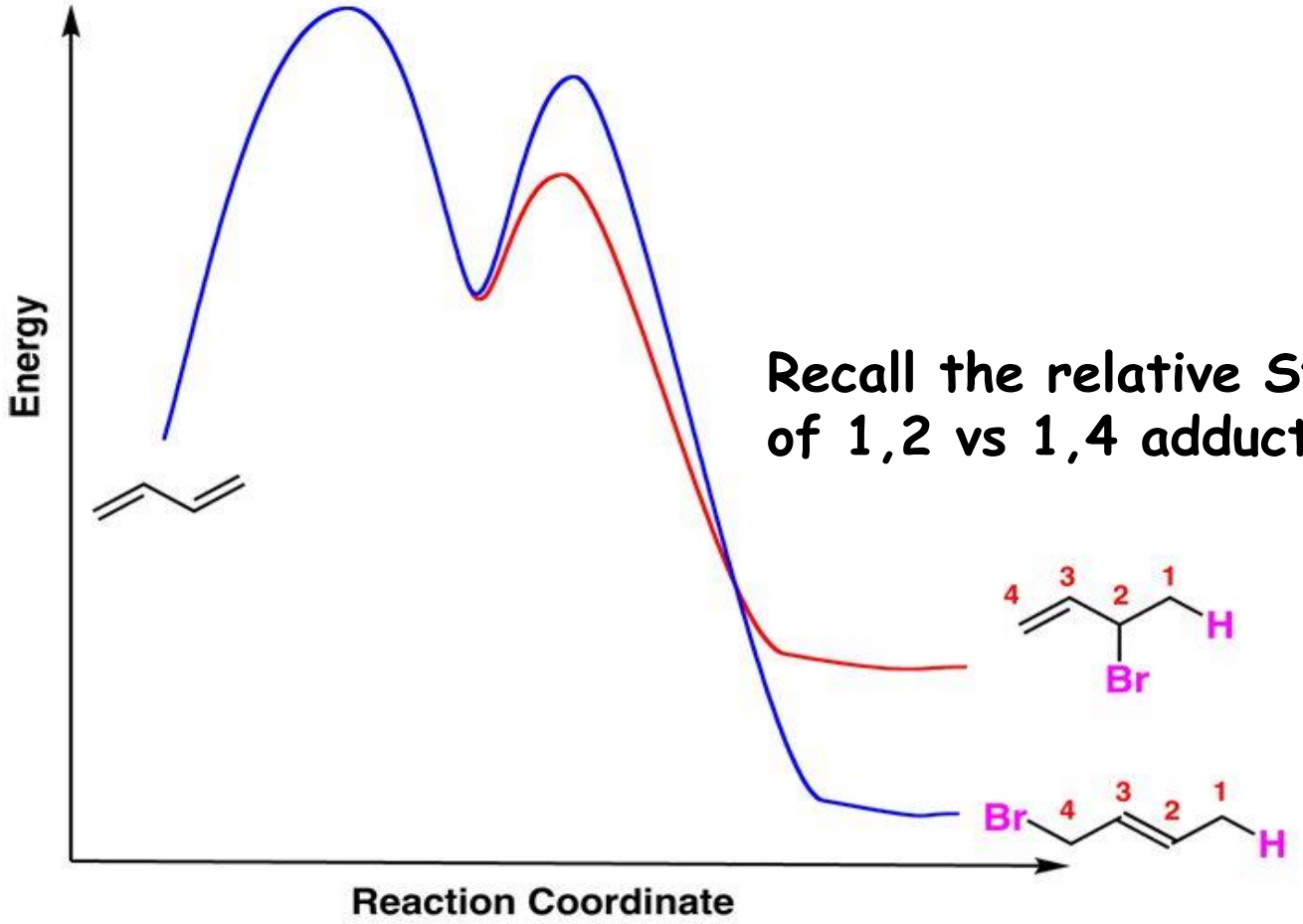
Kinetic Control

- When a reaction is under kinetic control, the composition of the product mixture is determined by the relative rates of formation of each product

Thermodynamic Control

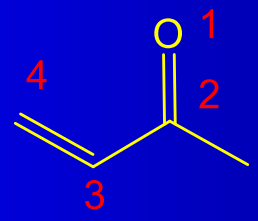
- When a reaction is under thermodynamic control, the composition of the product mixture is determined by the relative stabilities of each product

Reaction energy diagram for addition of HBr to butadiene

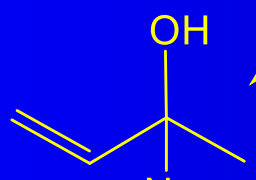


Recall the relative Stability of 1,2 vs 1,4 adducts

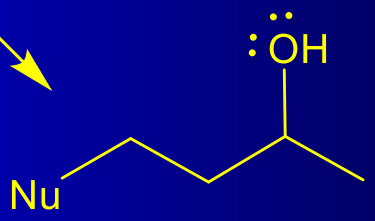
Conjugate Addition



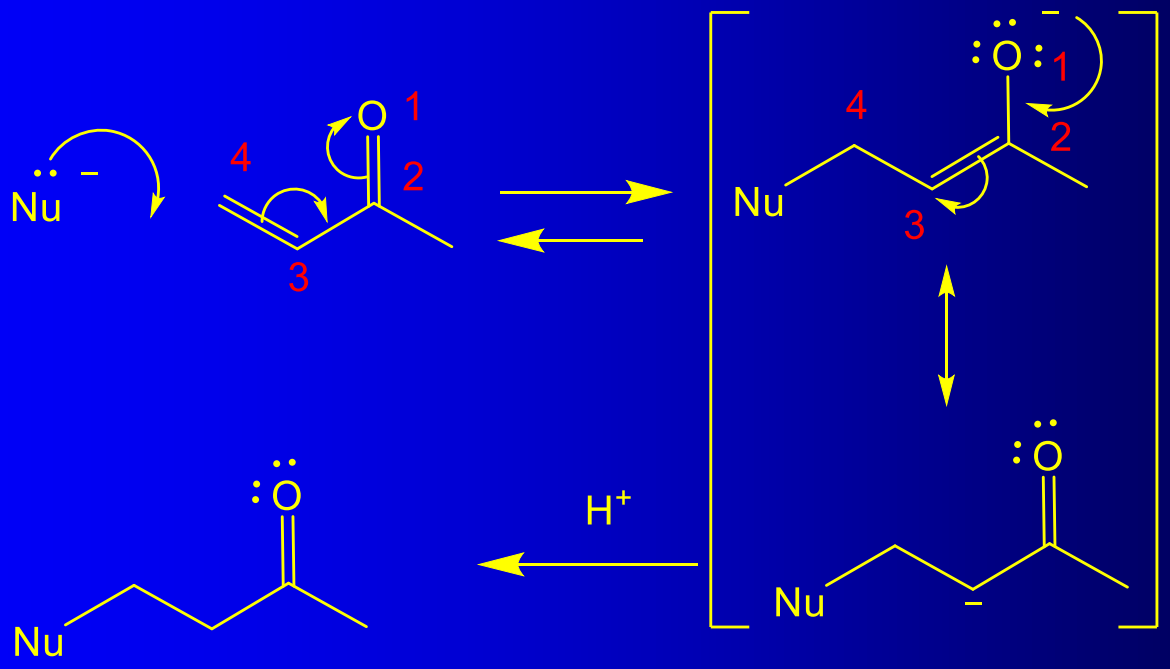
+ Nu



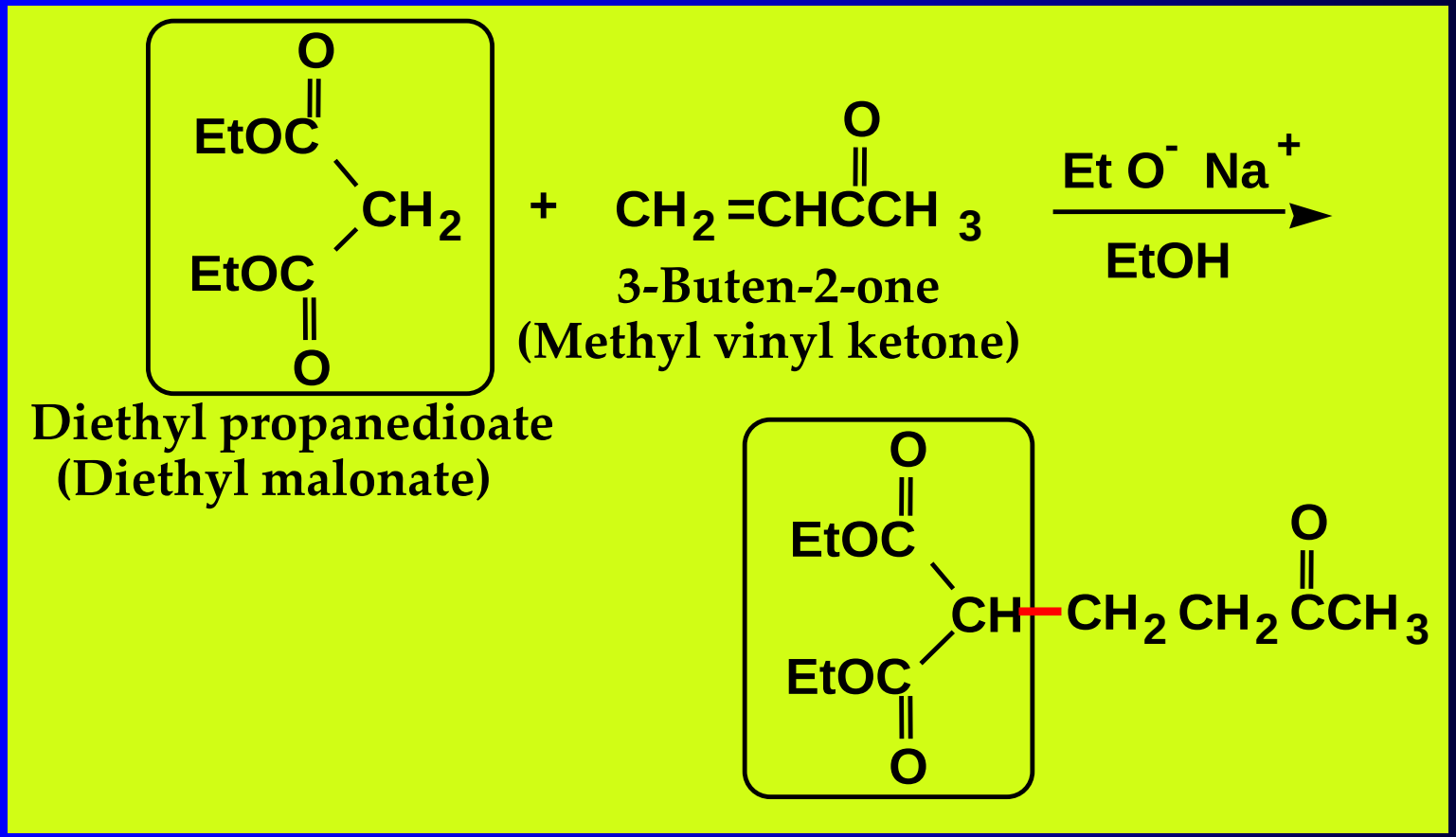
1,2 addition



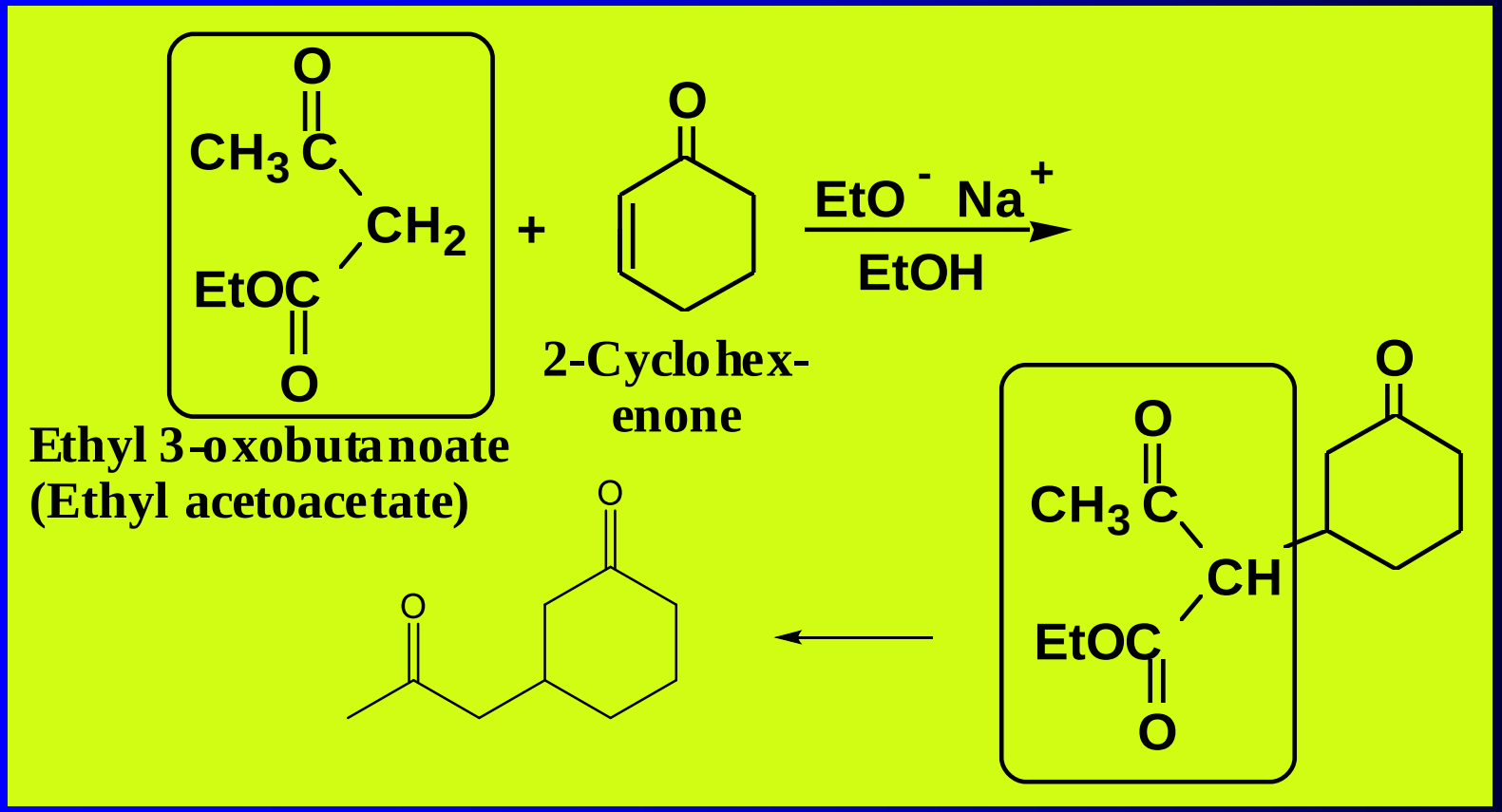
1,4 addition or
Conjugate addition



Michael Reaction

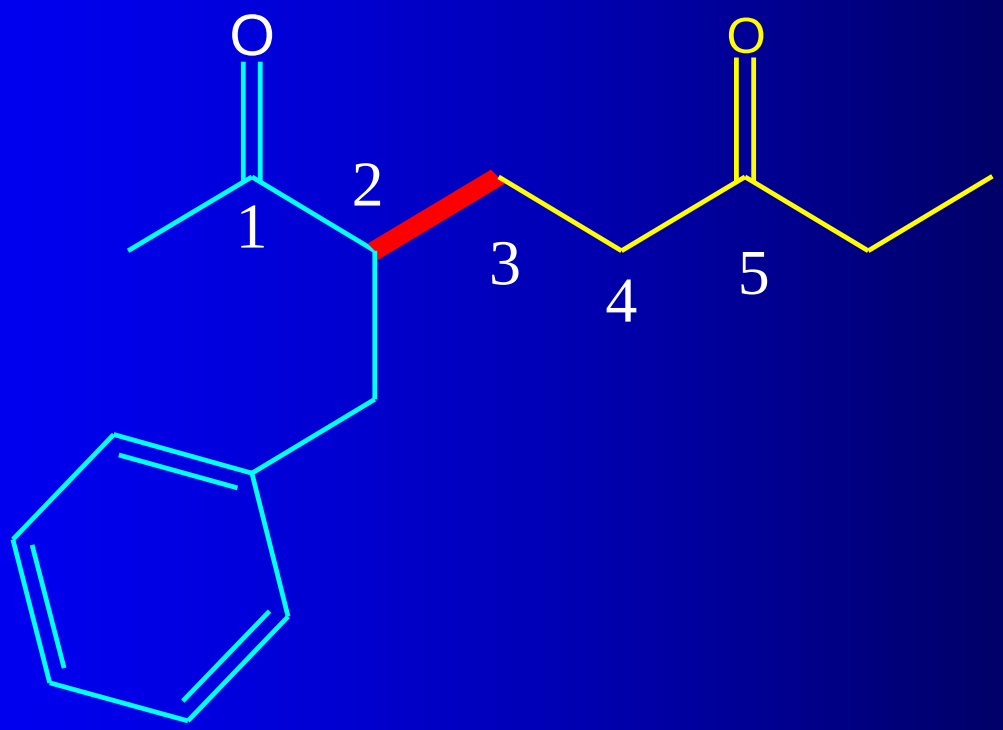


Michael Reaction



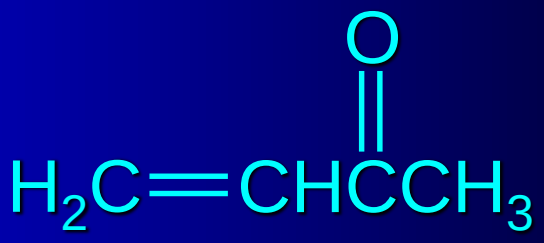
Michael Addition

- The Michael reaction is a useful method for forming carbon-carbon bonds….1,5 dicarbonyls

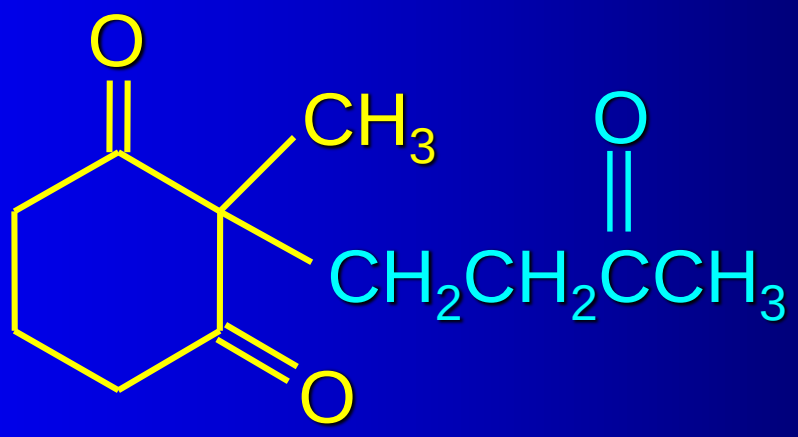


The Robinson Annelation: 1. Michael addition

+

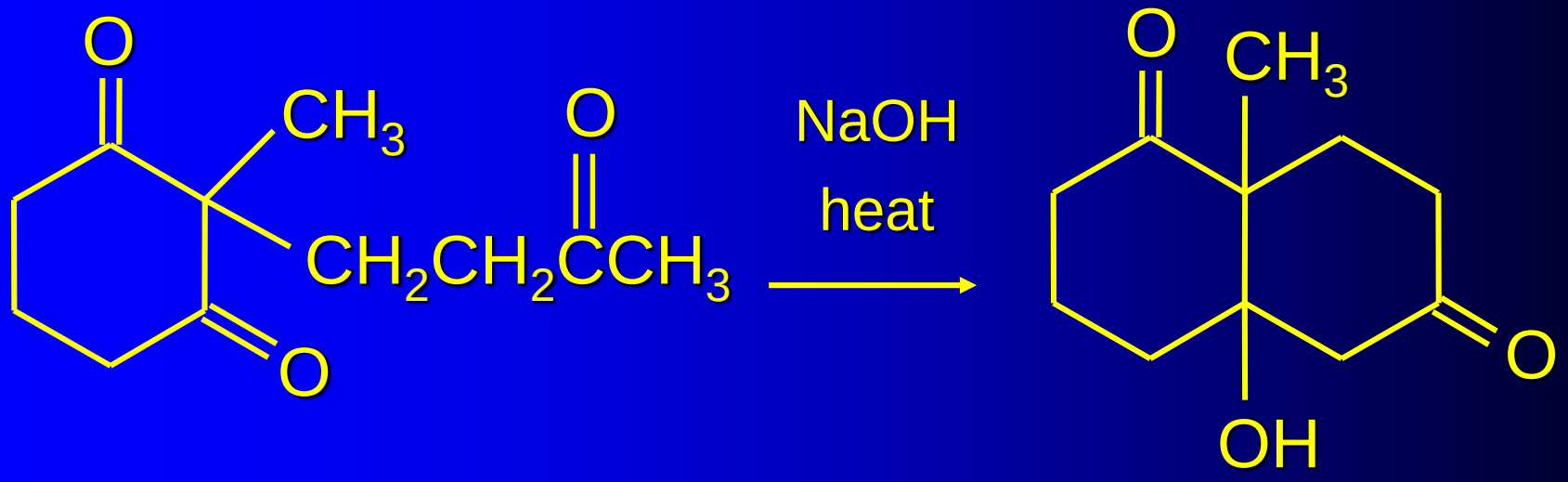


KOH, methanol



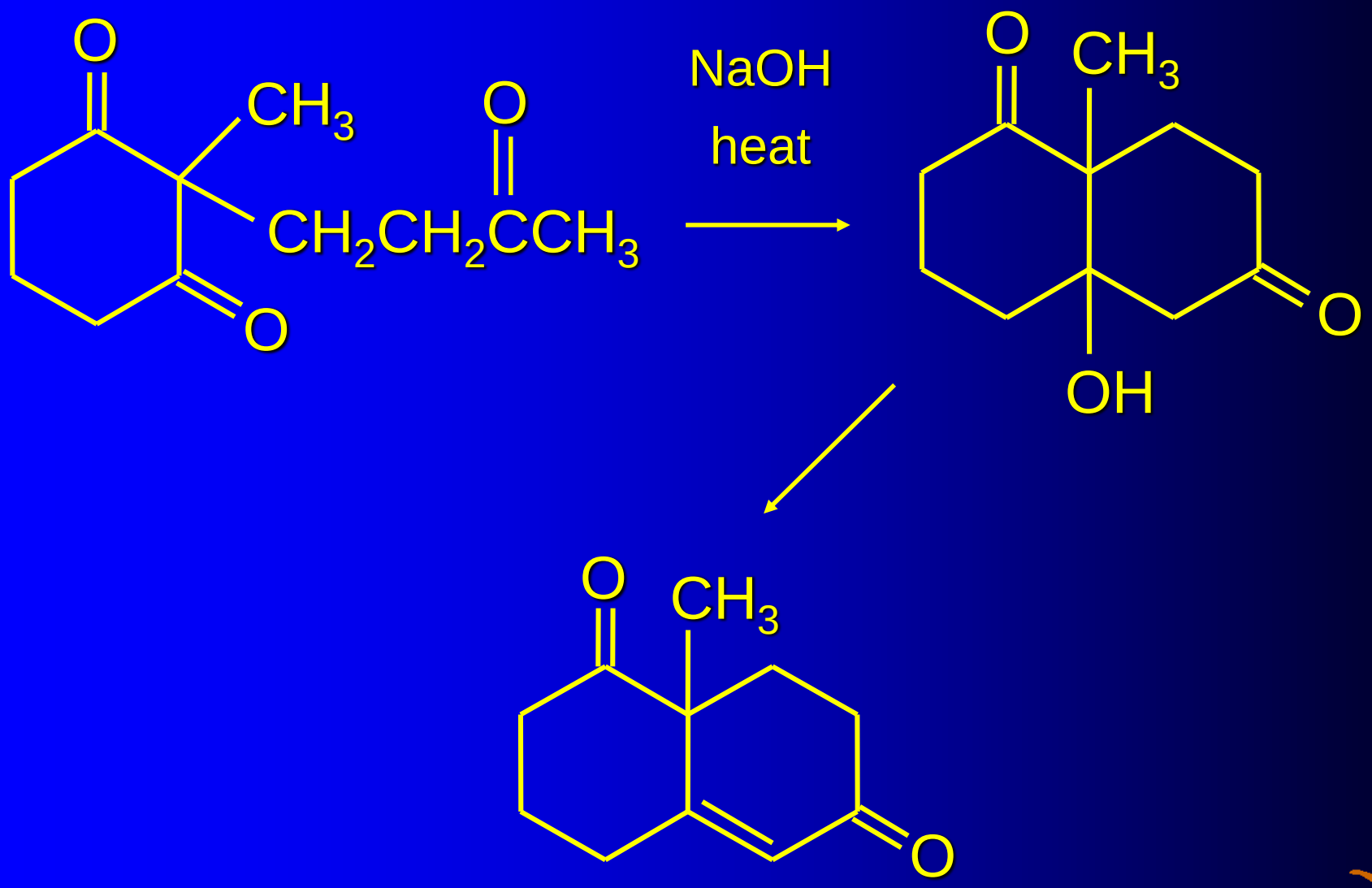
Robert Robinson
Nobel 1947

Robinson annelation: 2. aldol condensation

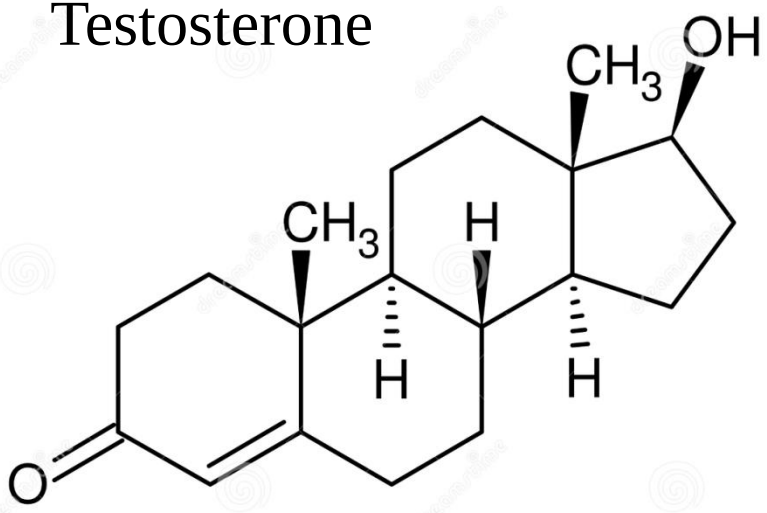


not isolated;
dehydrates under
reaction conditions

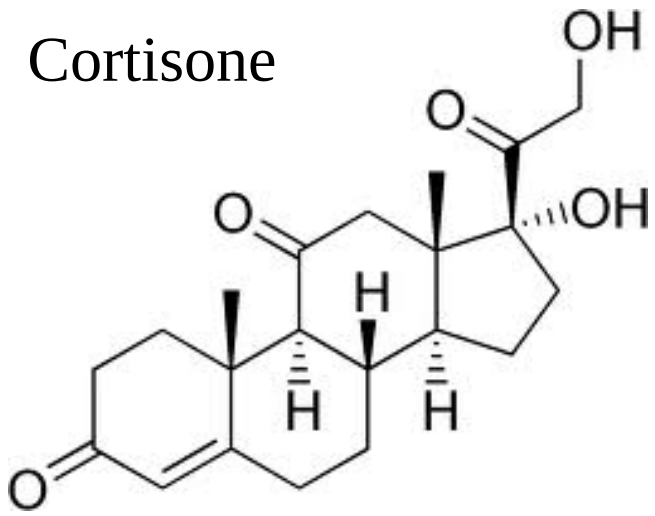
Robinson annelation: 3. elimination



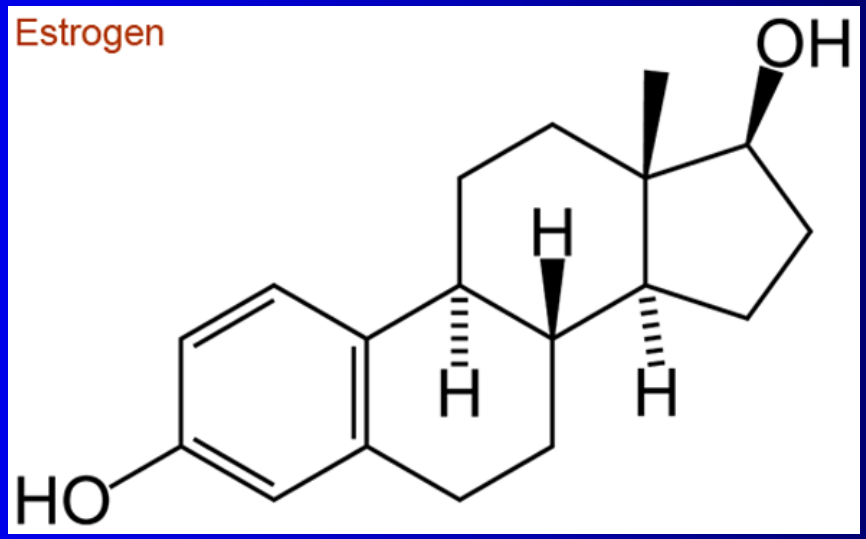
Testosterone



Cortisone



Estrogen



The Signature Page

Claisen Condensation: β-ketoesters

Dieckmann: Cyclic β-ketoesters

Aldol: α, β-unsaturated aldehydes and ketones

Acetoacetic ester synthesis: decorated acetones

Malonic ester synthesis: decorated acetic acids

Michael Reaction: 1-5 dicarbonyl compounds

Grignard Reaction: Alcohols

Wittig Reaction: Alkenes. …, etc

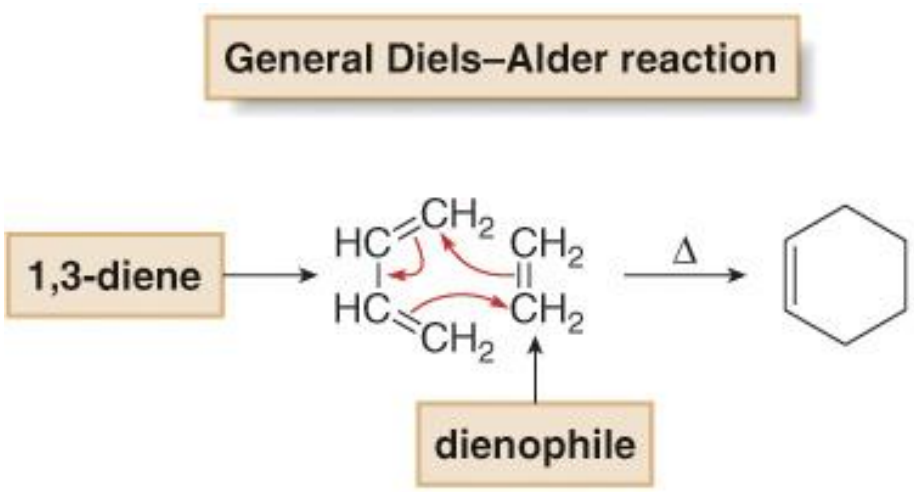
The Diels-Alder Reaction

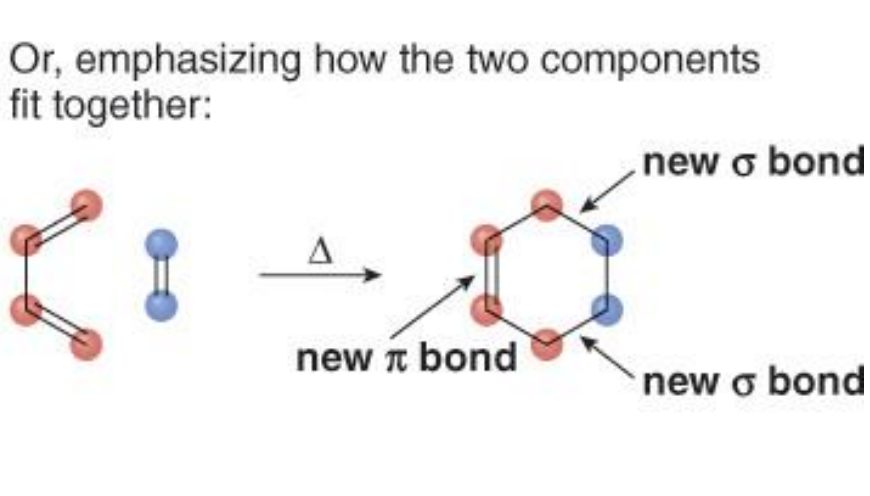
Otto Paul Hermann Diels
1876-1954

Kurt Alder
1902-1958

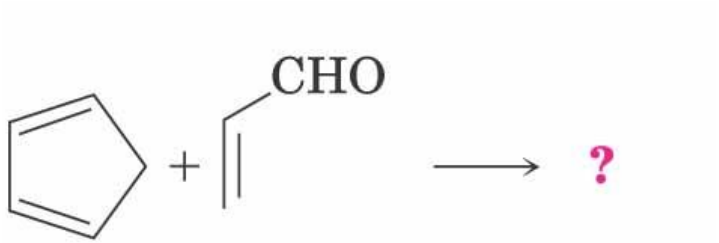
Diels-Alder Reaction:

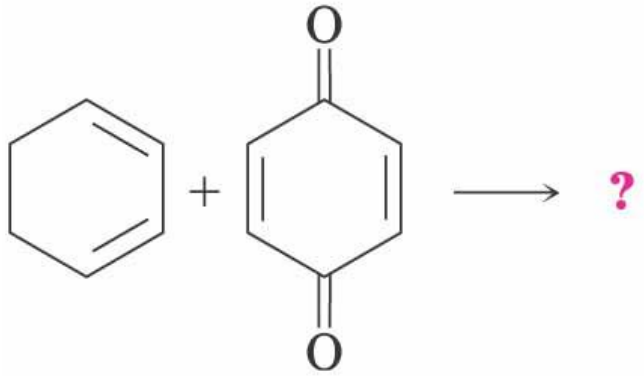
- **The Diels-Alder reaction is an addition reaction between a 1,3-diene and an alkene (called a dienophile), that forms a new six-membered ring.**

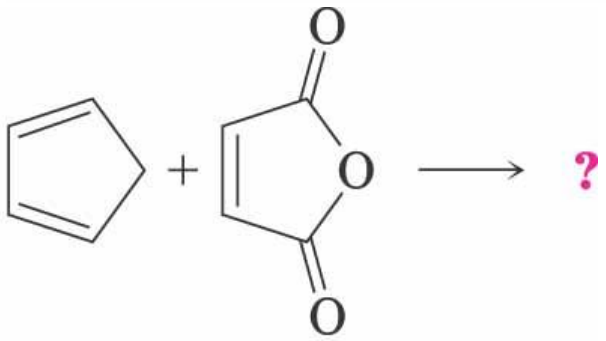




Predict the products





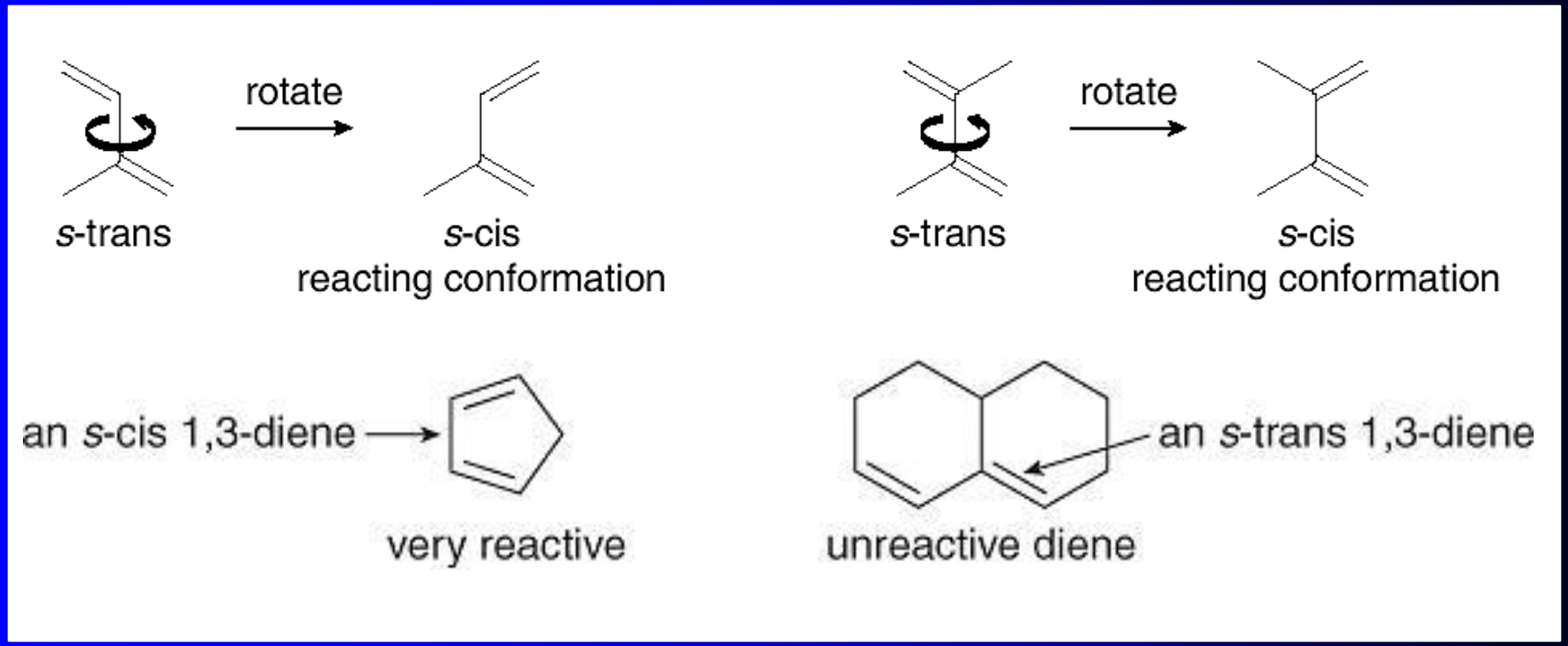


All Diels-Alder reactions:

1. are initiated by heat; that is, the Diels-Alder reaction is a thermal reaction.
2. form new six-membered rings.
3. involve breaking three π bonds and making two new σ bonds and one new π bond.
4. are concerted; that is, all bonds are broken and new bonds formed in a single step.

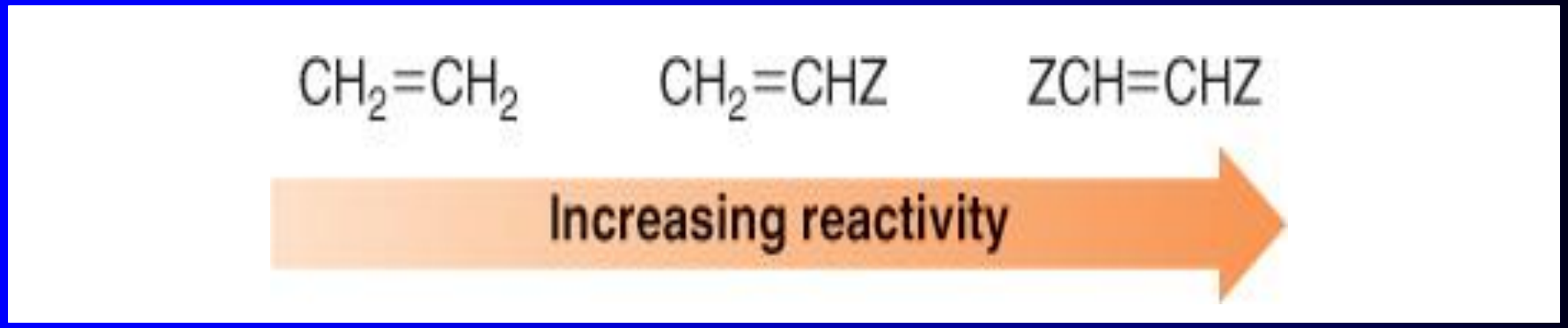
4 Rules that govern the Diels-Alder reaction

1. The diene can react only from the *s*-cis conformation.



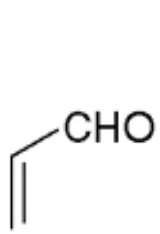
2. Electron-withdrawing substituents in the dienophile increase the reaction rate.

- The conjugated diene acts as a nucleophile and the dienophile acts as an electrophile.
- Electron-withdrawing groups make the dienophile more reactive
- If Z is an electron-withdrawing group, then the reactivity of the dienophile increases as follows:

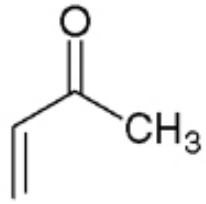


Common dienophiles

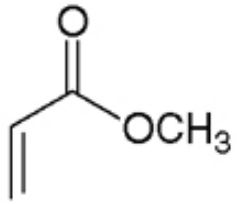
The carbonyl group is electron-withdrawing and activates dienophiles



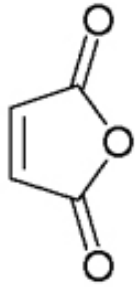
acrolein



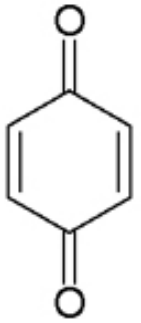
methyl vinyl ketone



methyl acrylate

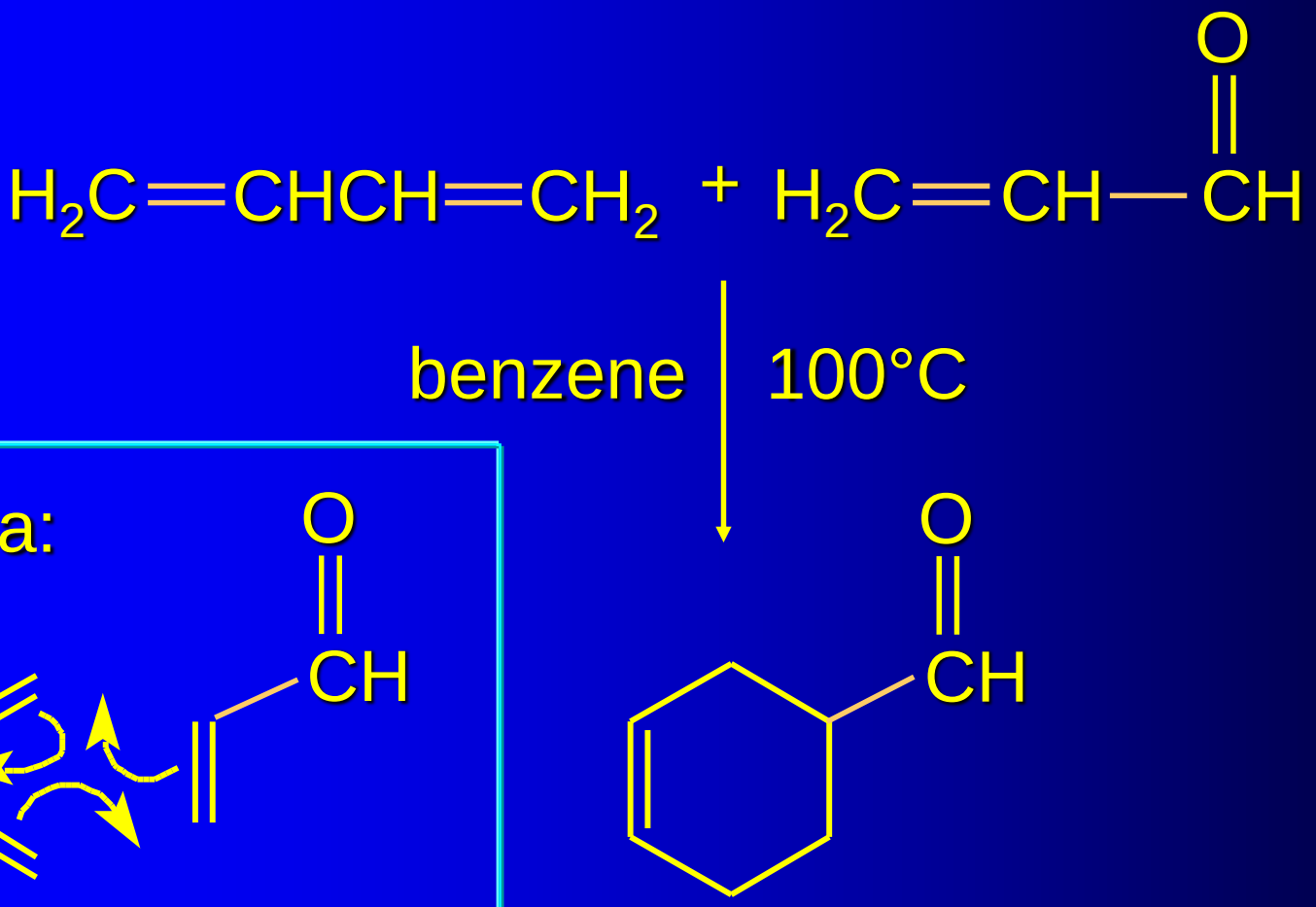


maleic anhydride

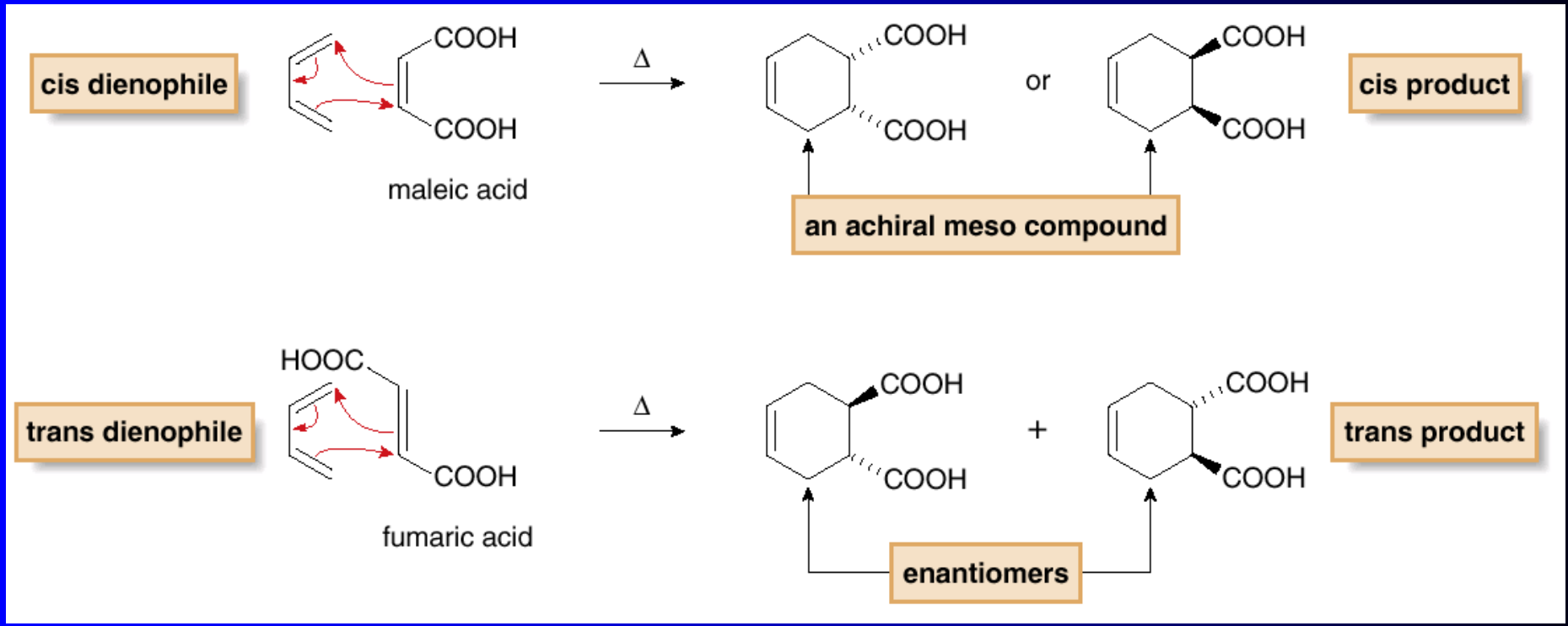


benzoquinone

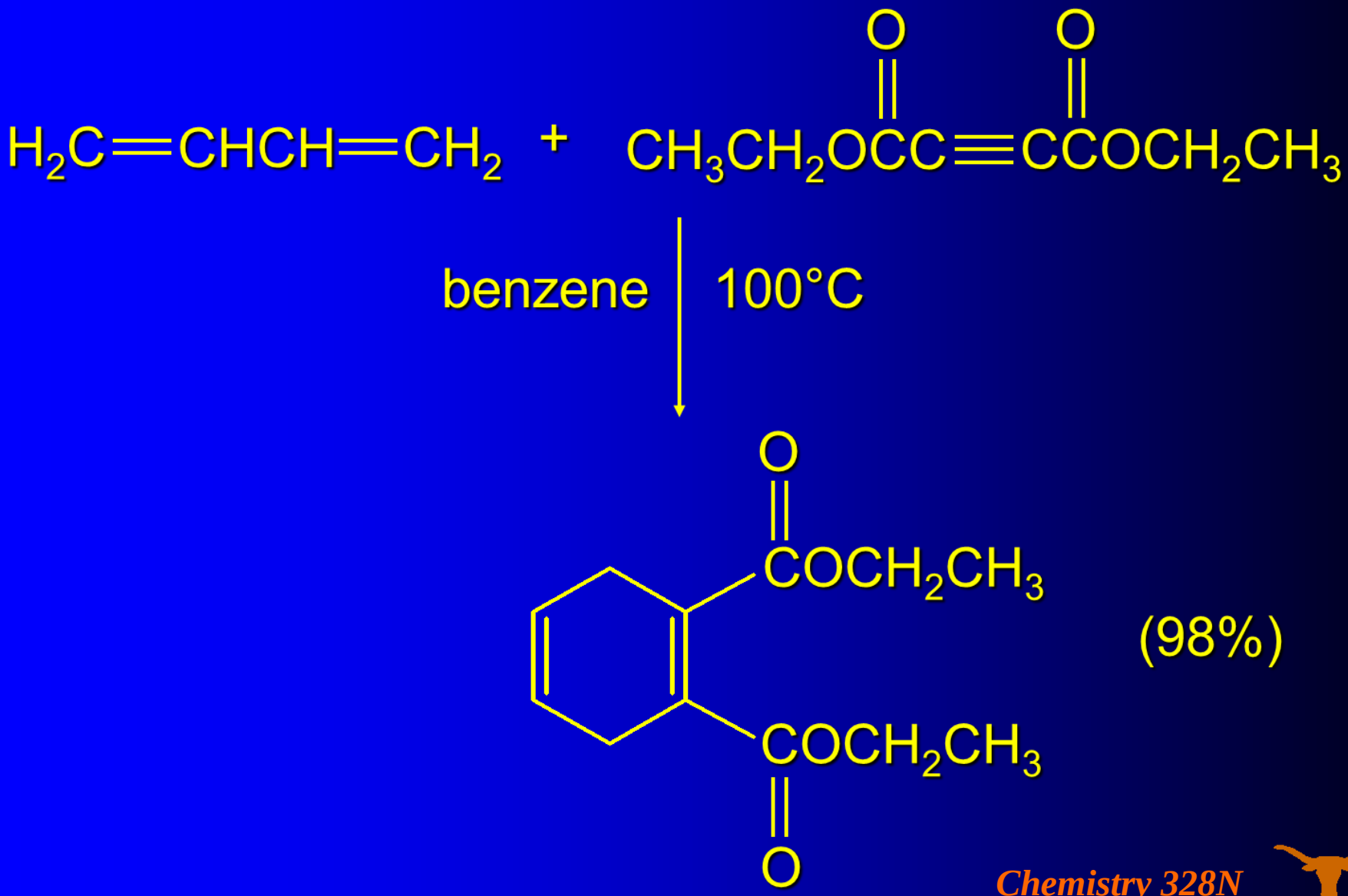
Example



3. The stereochemistry of the dienophile is retained.

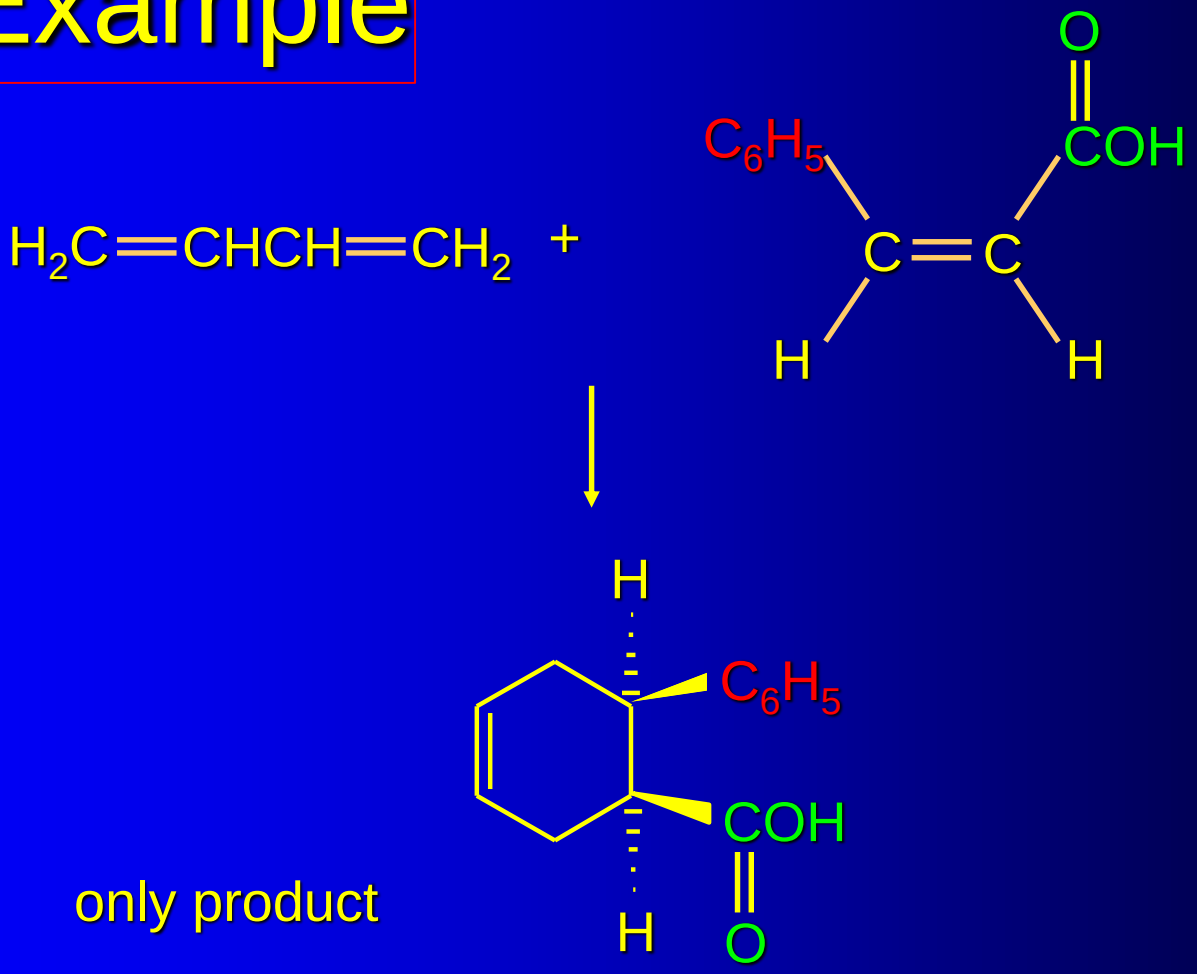


Acetylenic Dienophile



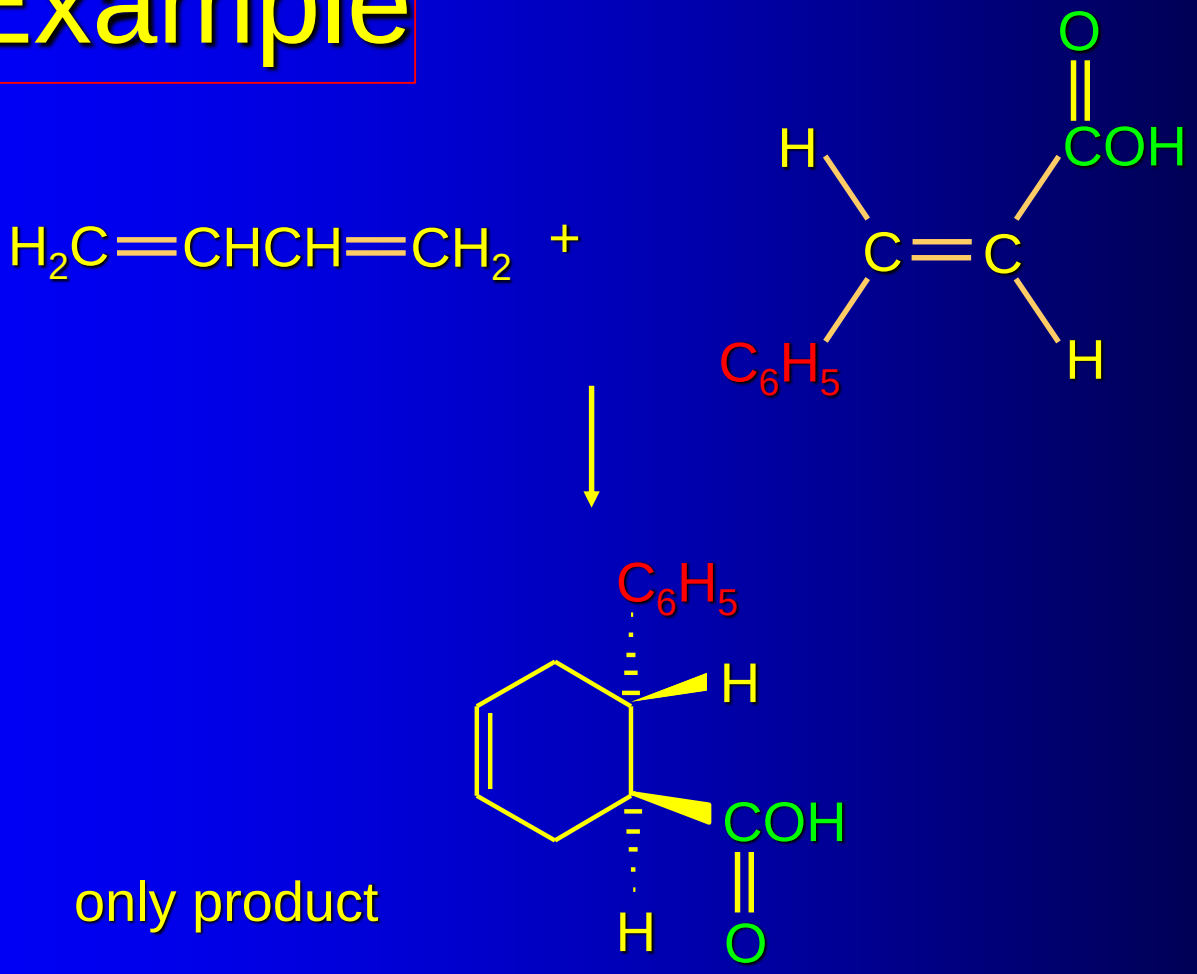
(98%)

Example

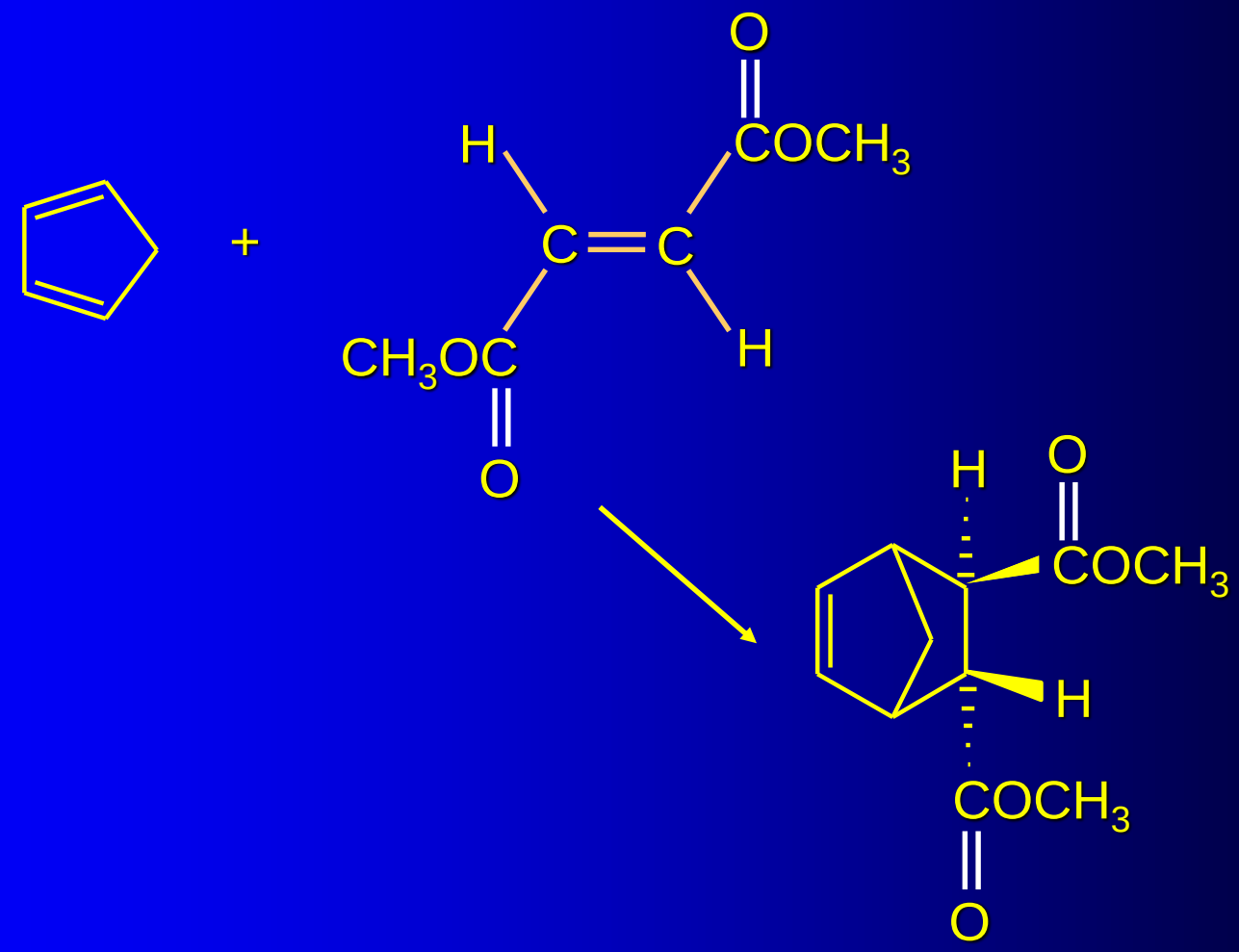


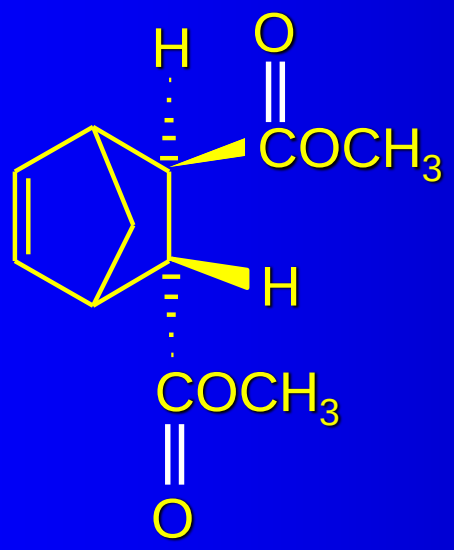
only product

Example

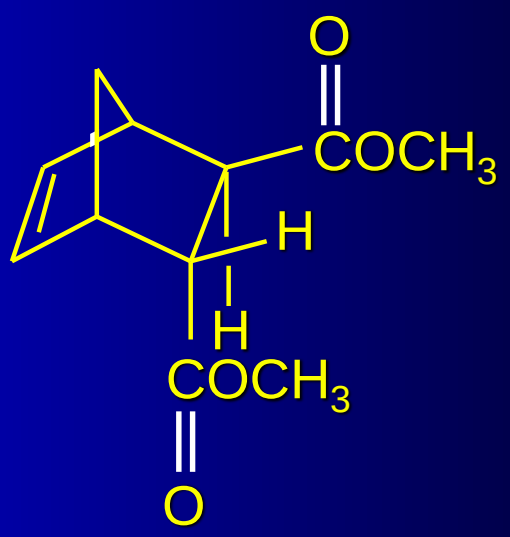


only product


O
COCH3
H
C
C
H
CH3OC
O
H
O
COCH3
H
COCH3
O



is the same as

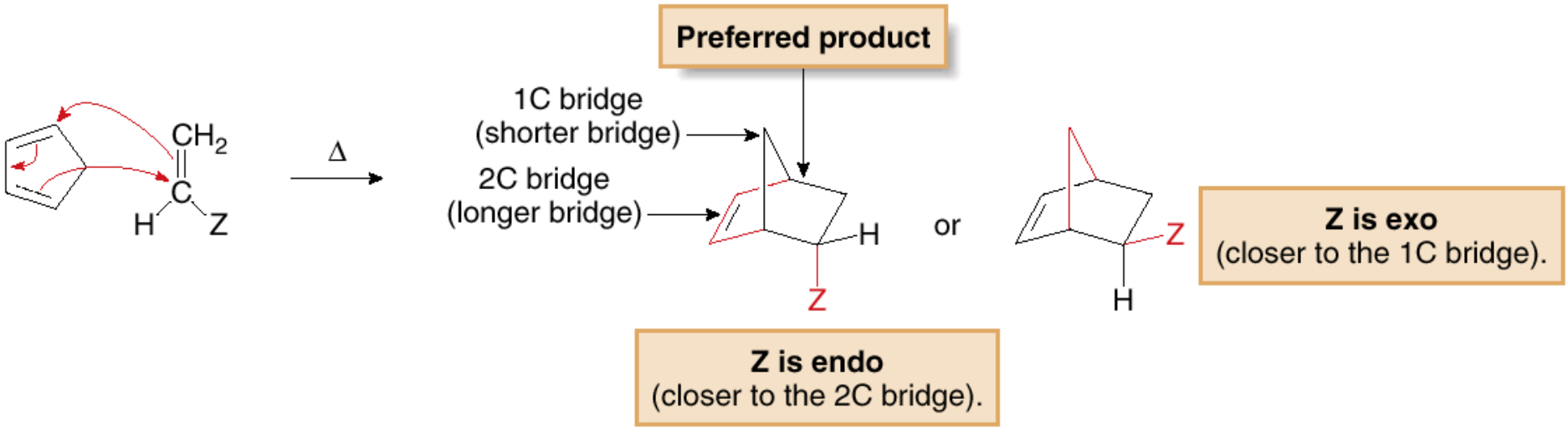


4. When endo and exo products are possible, the endo product is preferred.

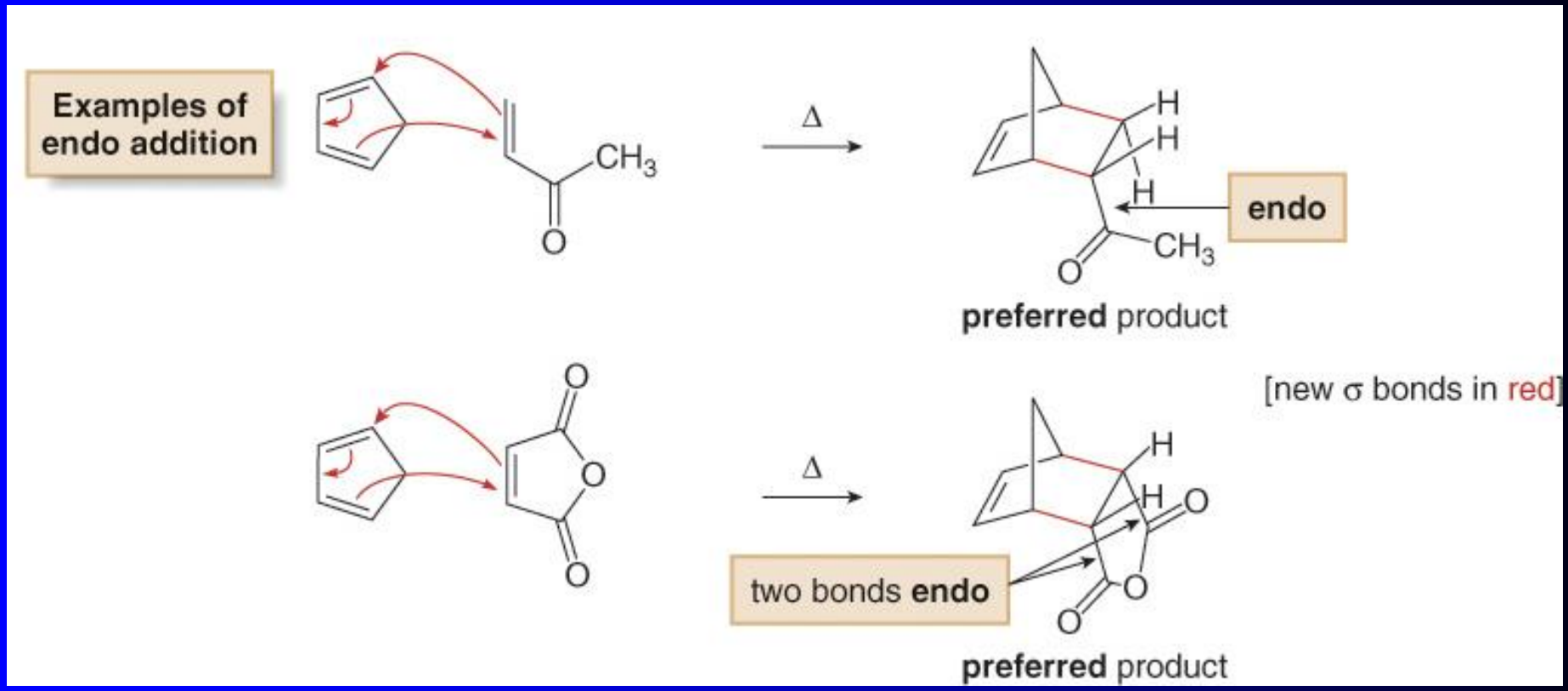
endo and exo indicate the orientation of Z.

endo = on the side of the big bridge

exo = on the side of the small bridge

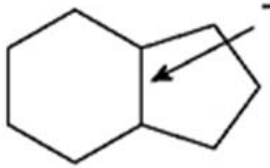


The endo product is preferred!



Some nomenclature

A fused bicyclic system



This C–C bond is **shared** by both rings.

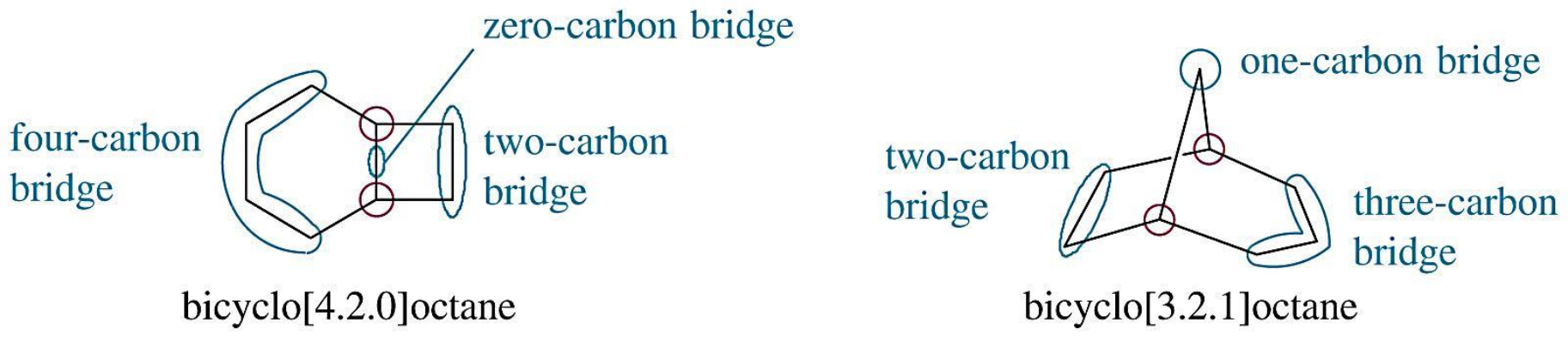
- One bond is shared by two rings.
- The shared C's are adjacent.

A bridged bicyclic system

These C's are **shared** by two rings.

- Two non-adjacent atoms are shared by both rings.

Nomenclature of Bicyclic Systems

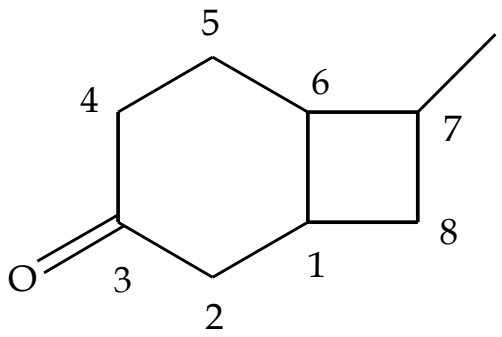


Bicyclo [#.#.#]alkane

Where # is the number of carbons on the bridges (in decreasing order) and the alkane name includes all the carbons in the compound.

Nomenclature of Bicyclic Systems

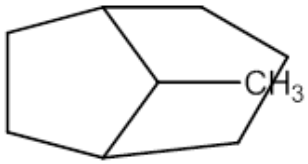
Numbering begins at a bridgehead, goes around the **largest** ring first, to give the lowest number to any functionality on the ring.



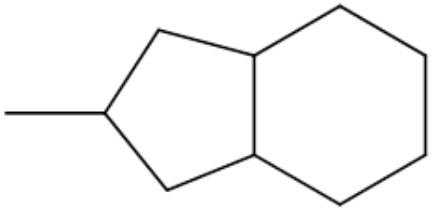
7-Methyl-bicyclo[4.2.0]octan-3-one

Some nomenclature

- If substituents are present, number the bridge ring system beginning at on bridge-head, proceeding first along the longest bridge to the other bridge-head. The shortest bridge is named last



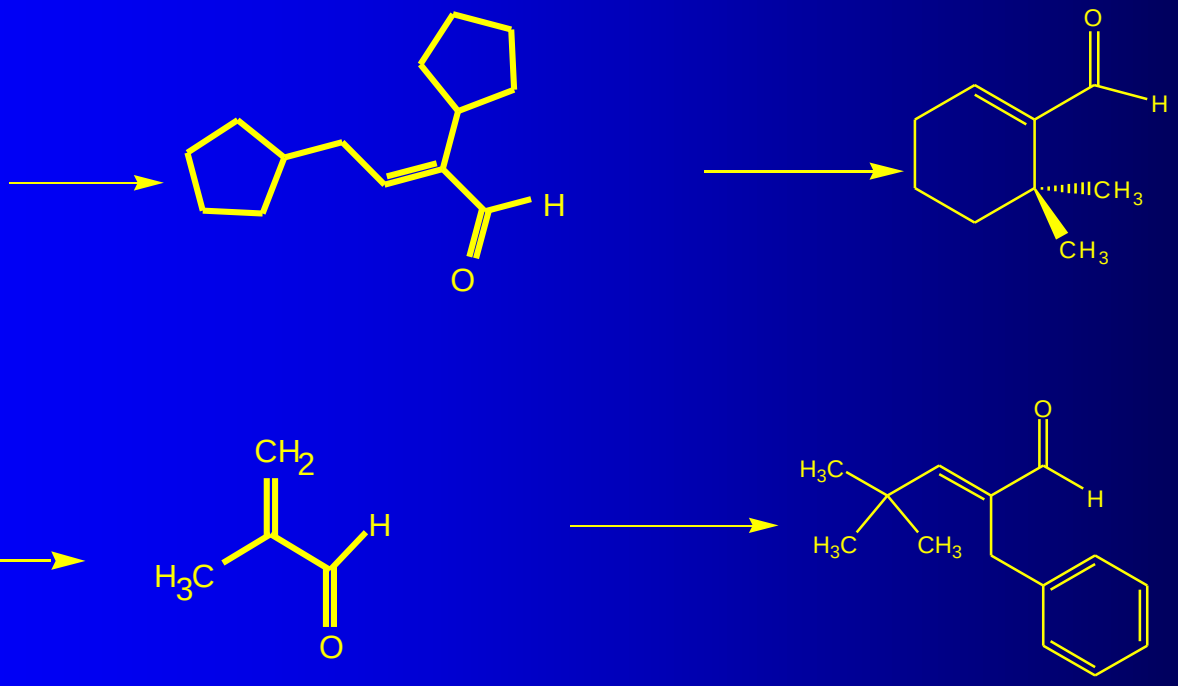
8-methylbicyclo[3.2.1]octane



8-methylbicyclo[4.3.0]nonane

Practice

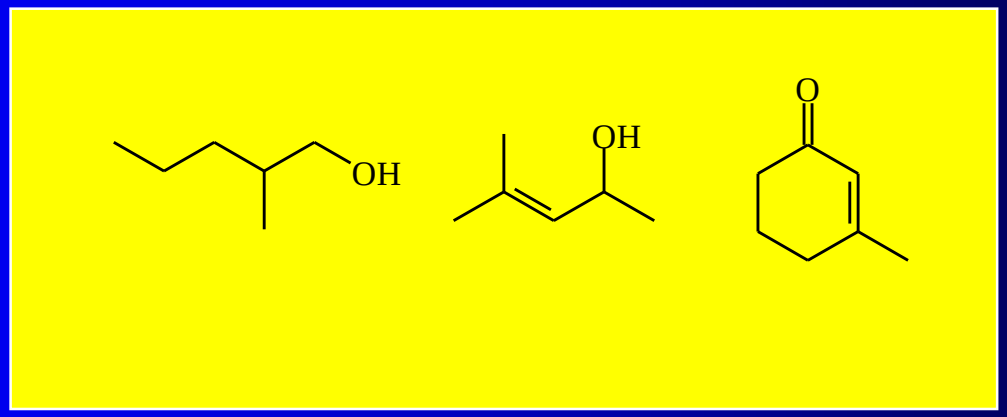
Aldol products from what ??



Practice Exercises

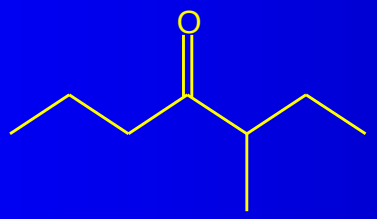
Disguised signatures!?

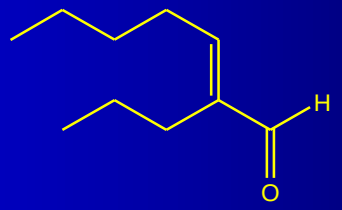
show how the following compounds could be synthesized by a path that Includes an aldol or mixed aldol condensation,

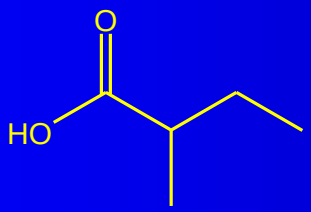


Don’t let disguises fool you!

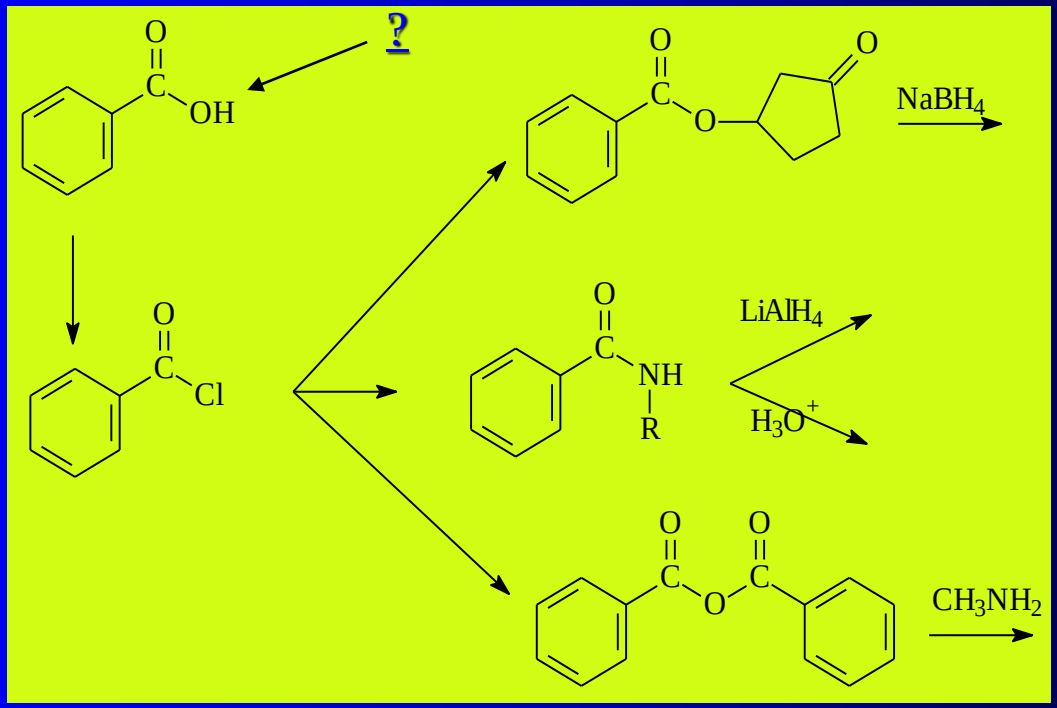
Make these starting with ethyl acetate or diethyl malonate and anything else





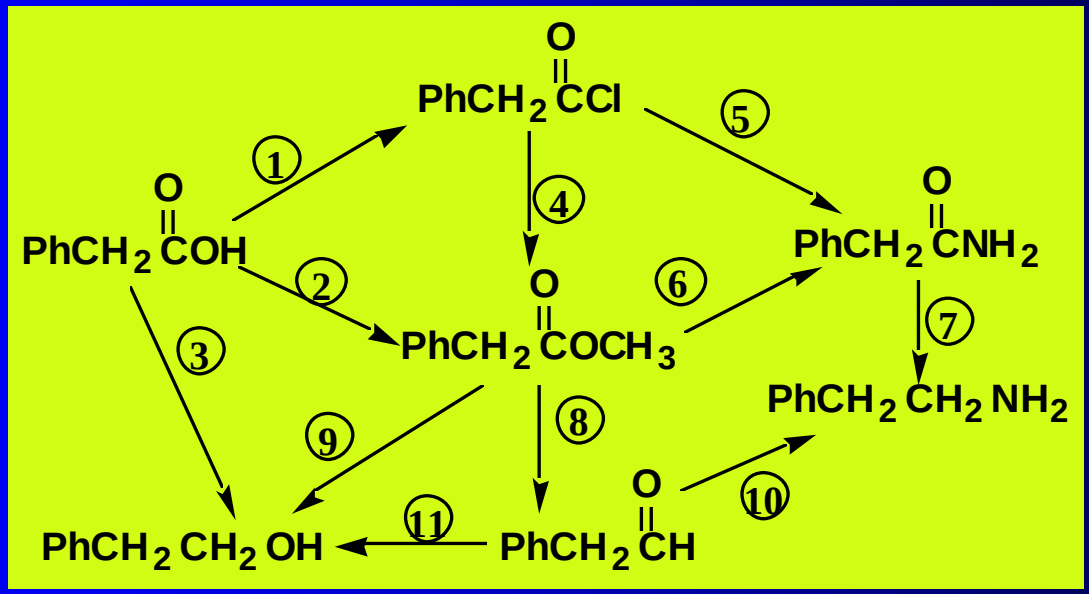


How far can you expand this web?



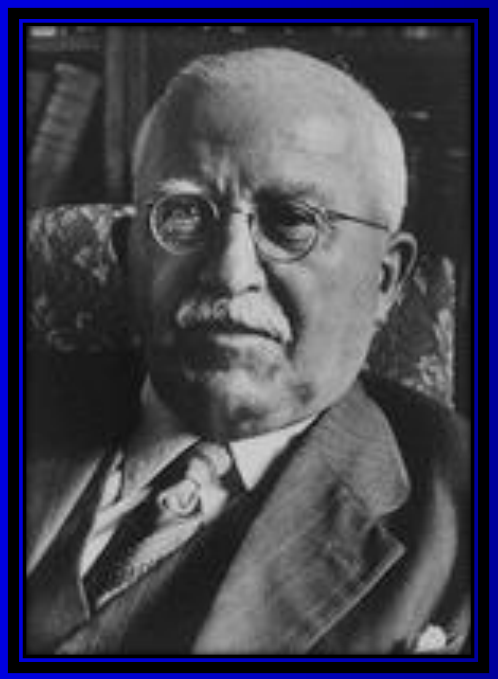
Interconversions

- Problem: show reagents and experimental conditions to bring about each reaction



Next..... *POLYMERS*

Jöns Jacob Berzelius
(1779-1848)



Hermann Staudinger
(1881-1965)

Wallace Hume Carothers
(1896-1937)