

Recap- Selection Rules for Cycloaddition

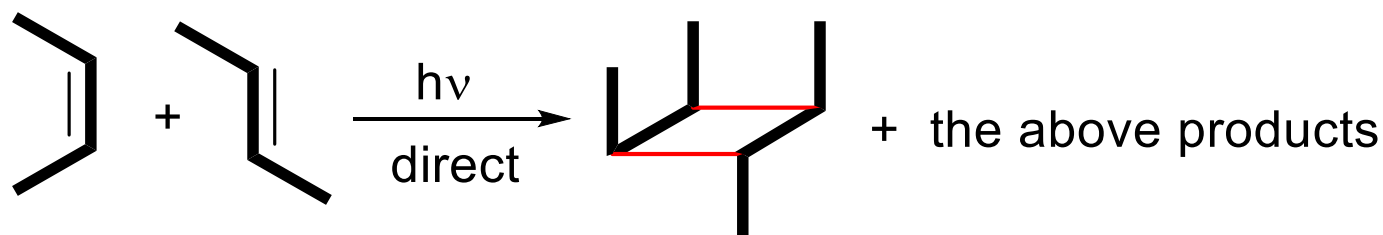
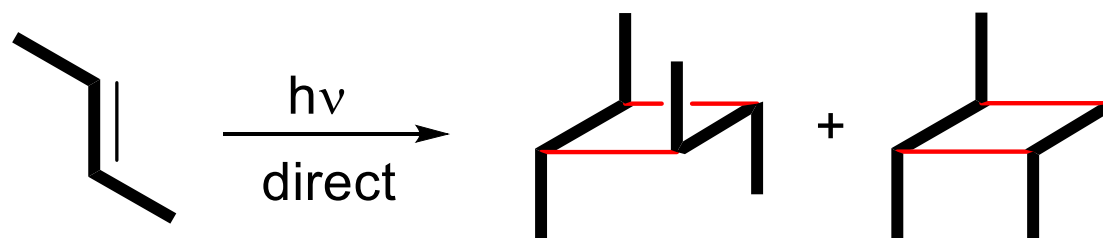
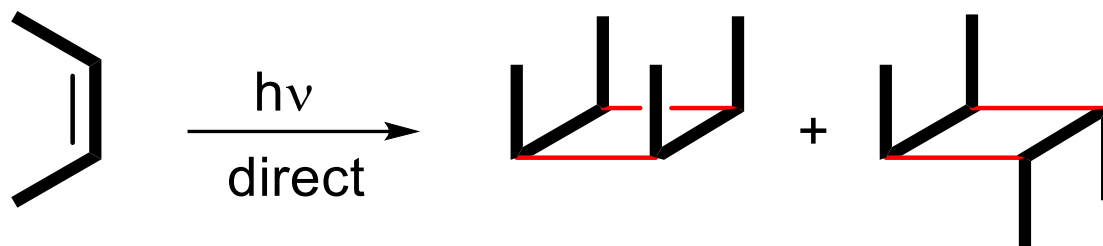
Cycloadditions involve **facial** interactions and not **side by side** interactions

System (total no. of electrons)	Mode of addition	Allowedness of the reaction	
		Thermal	Photochemical
$4n$	s/s	forbidden	allowed
$4n$	s/a	allowed	forbidden
$4n+2$	s/s	allowed	forbidden
$4n+2$	s/a	forbidden	allowed

(n = natural number)

Since s/a mode is difficult to achieve mainly the s/s mode is observed

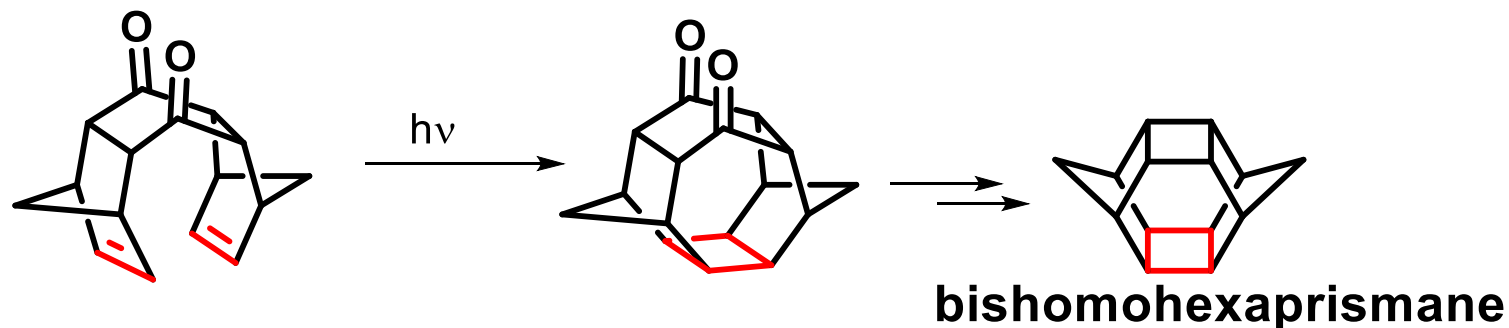
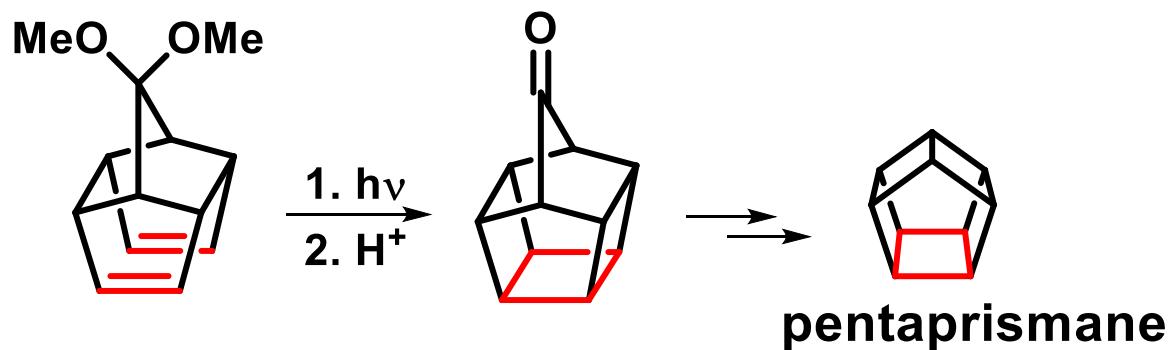
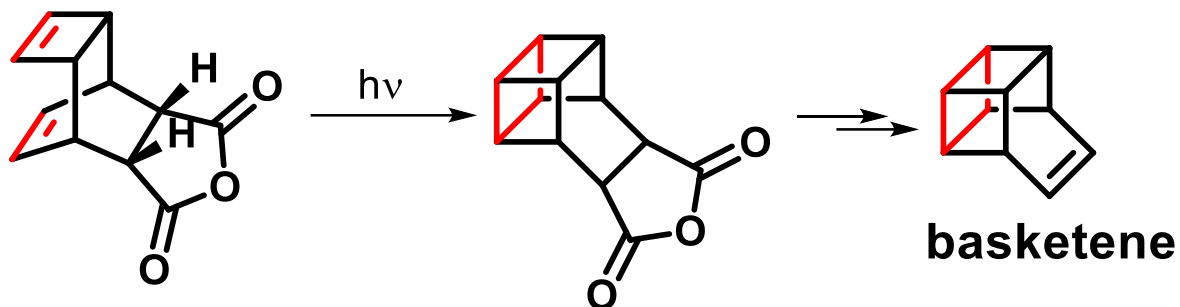
$2\pi + 2\pi$ Cycloaddition



Products formed due to suprafacial-suprafacial interactions

$2\pi + 2\pi$ Intramolecular Cycloaddition

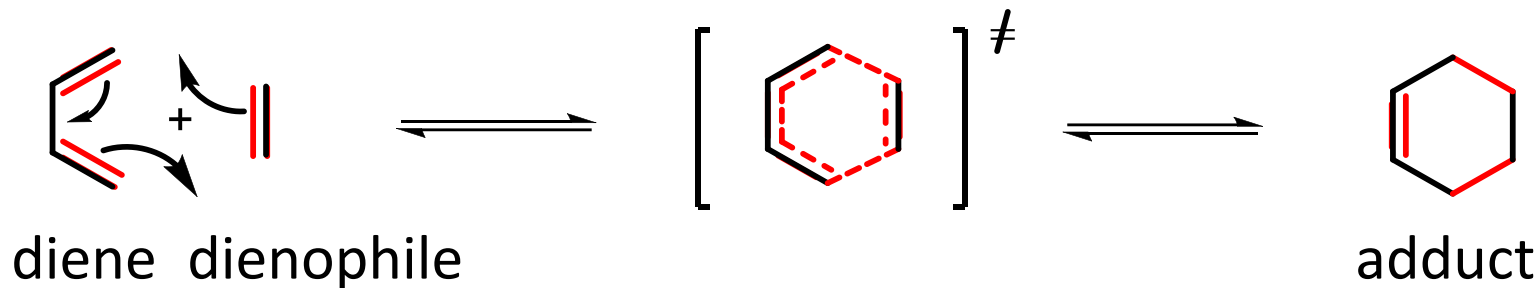
Interesting Synthetic Applications



Provides access to strained caged compounds

$4\pi + 2\pi$ Cycloaddition

Diels-Alder Reaction



Thermal cycloaddition between a conjugated diene and a dienophile
Discovered by Otto Diels and Kurt Alder (Nobel prize 1950)



Diels



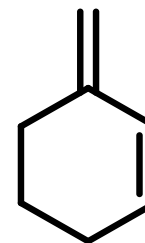
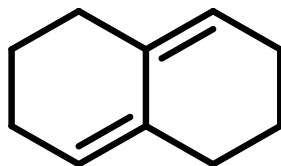
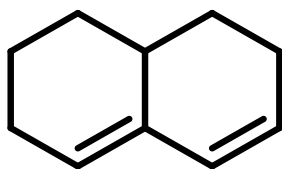
Alder

Reactivity - Diels-Alder Reaction

Requirement

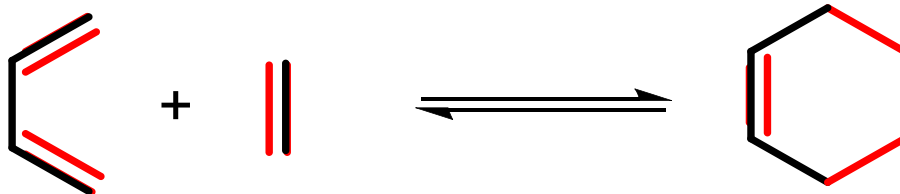
Diene should be in a **cisoid** (*s-cis*) conformation

Transoid dienes are unreactive



Unreactive as transoid structure is locked

$[4\pi + 2\pi]$



Diene

(2 double
bonds)

Dienophile

(likes diene)

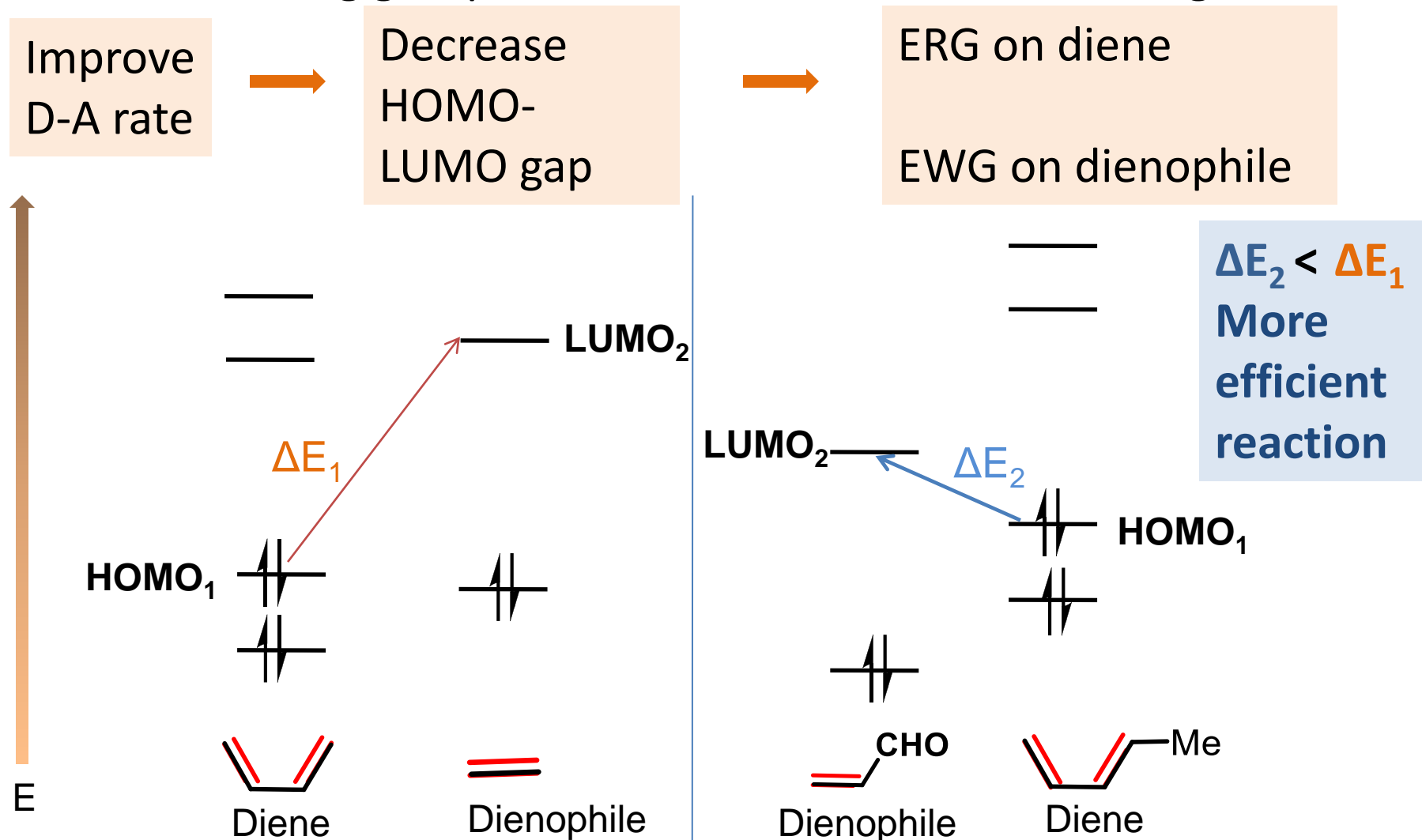
Commonly observed – Dienes – electron rich
Dienophile – electron deficient

‘Normal’ electron demand Diels Alder Reactions

Effect of Substituent on Reactivity

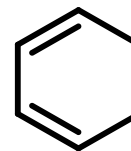
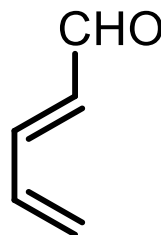
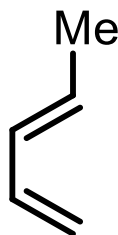
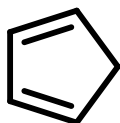
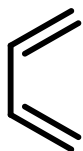
Electron releasing groups - Raise HOMO and LUMO energy

Electron withdrawing groups - Lower HOMO and LUMO energies

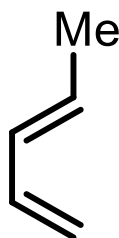


Small Activity

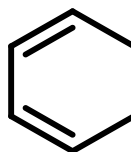
Compare the order of reactivity for these dienes



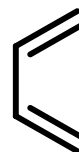
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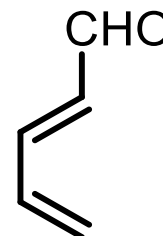
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Planar
Constrained
S-cis

Alkyl –
HOMO inc.

Not planar
Near *S-cis*

EWG –
HOMO dec.

Cis-Rule in Diels-Alder Reactions

Suprafacial-Suprafacial Interaction

Cis dienophile

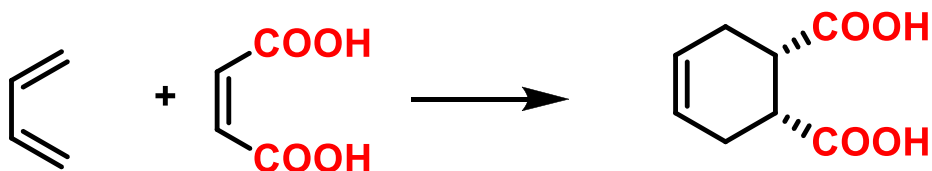


Adduct with *cis* subs.

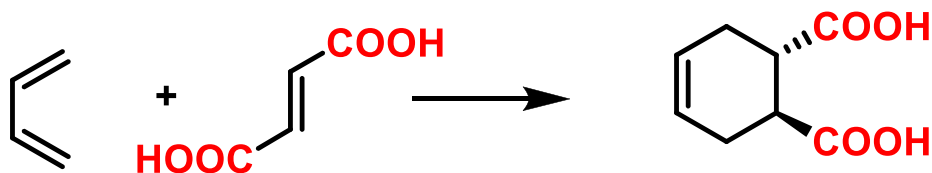
Trans dienophile



Adduct with *trans* subs.



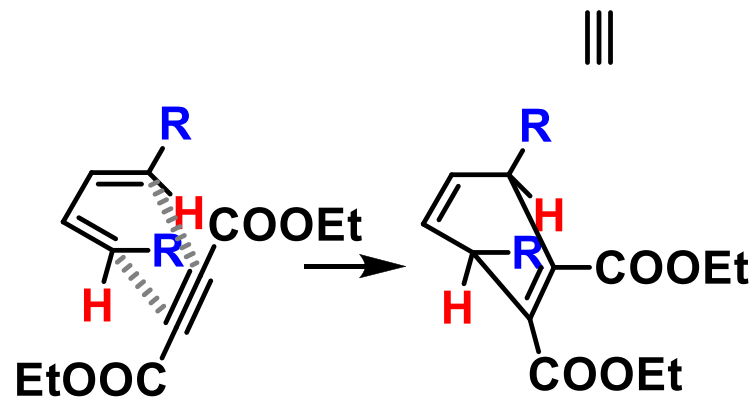
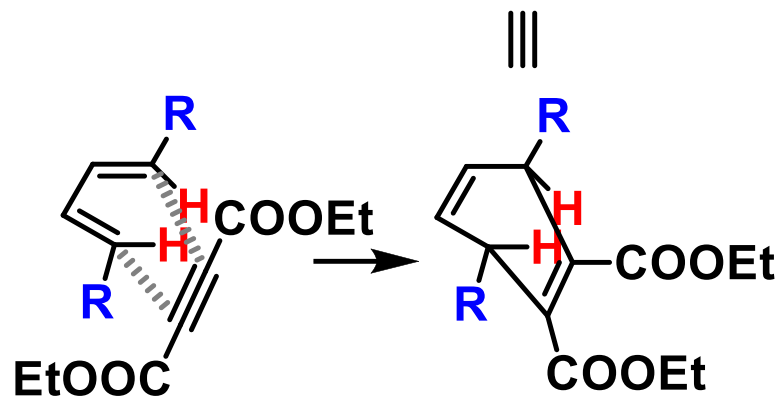
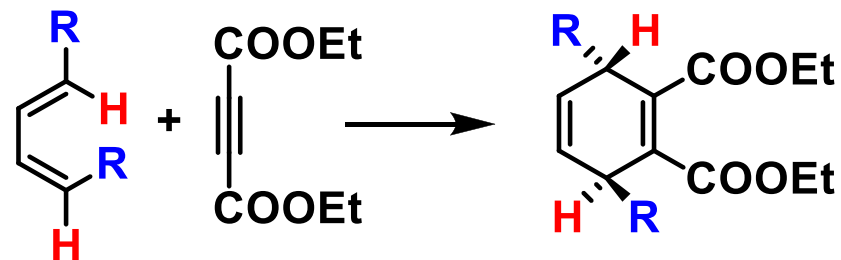
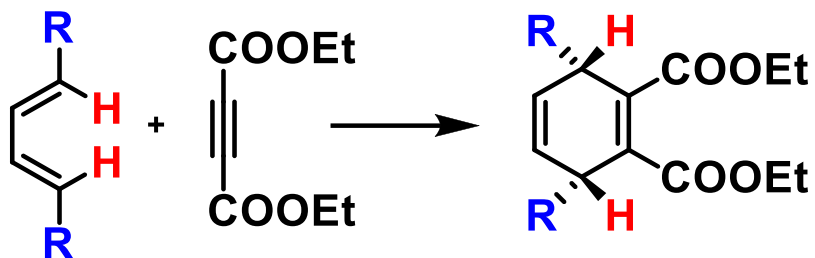
major product - **syn**



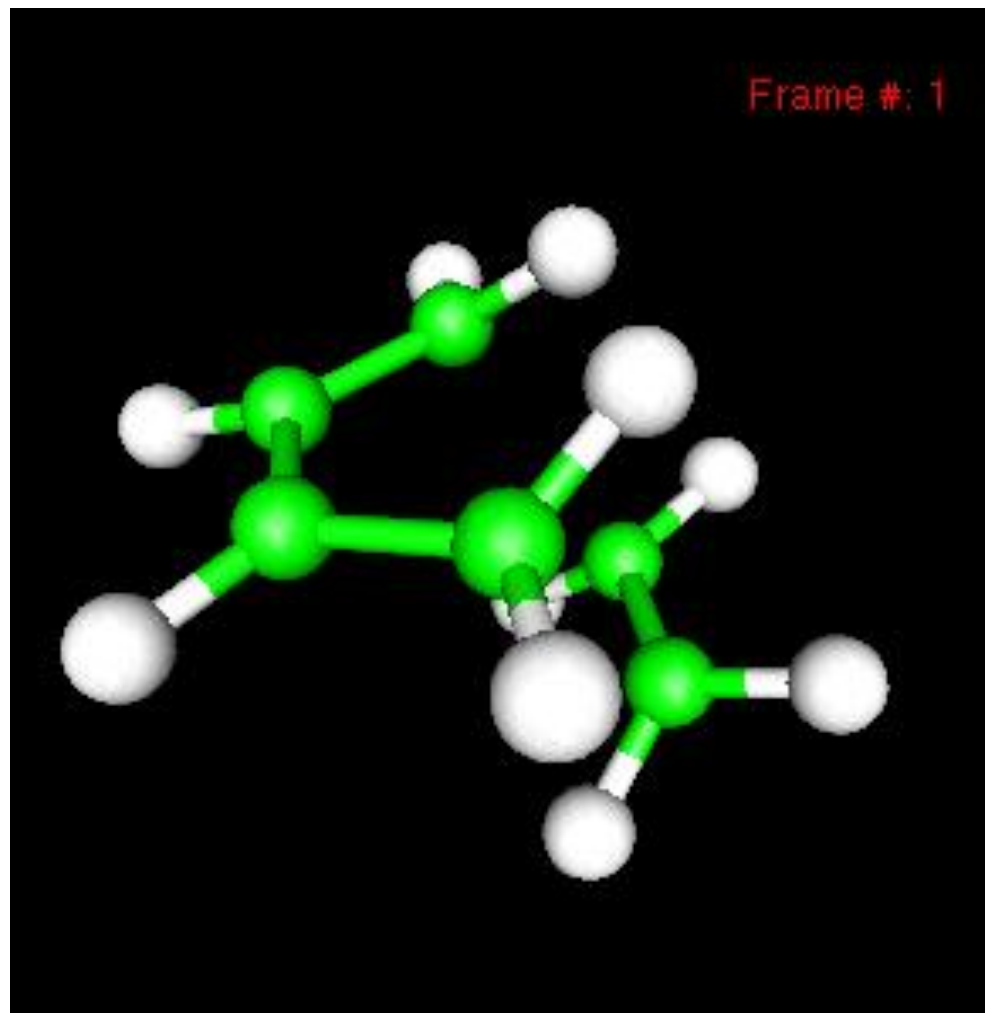
major product - **anti**

Rule holds true for dienes as well !

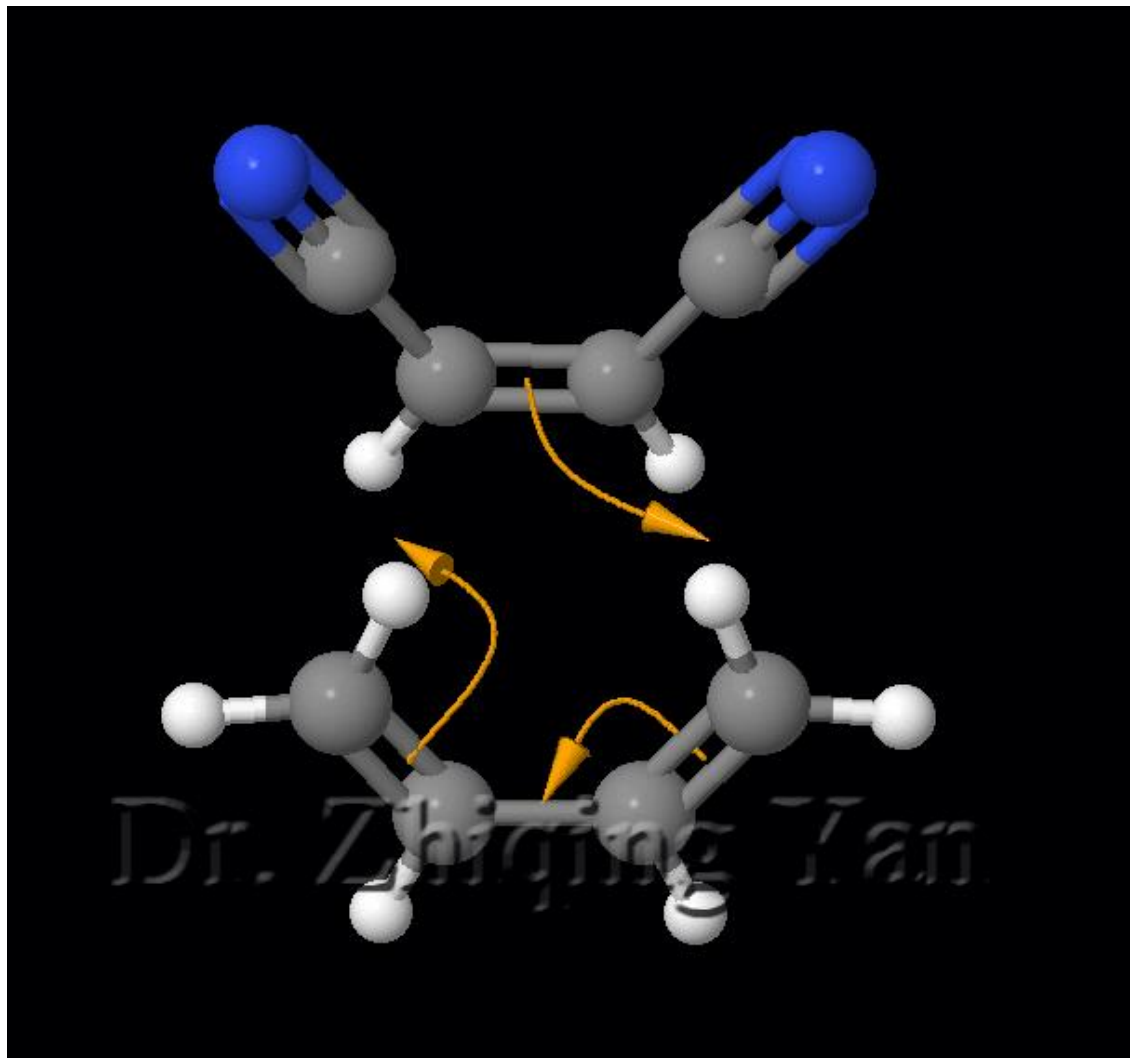
Cis Rule



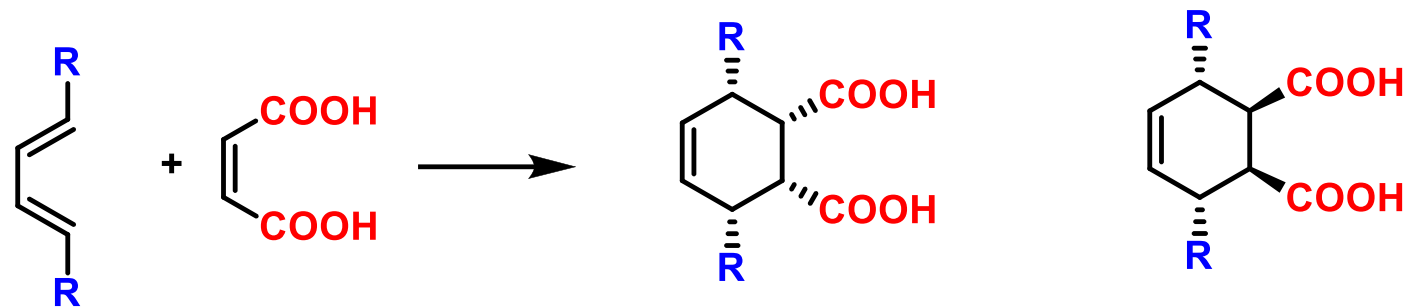
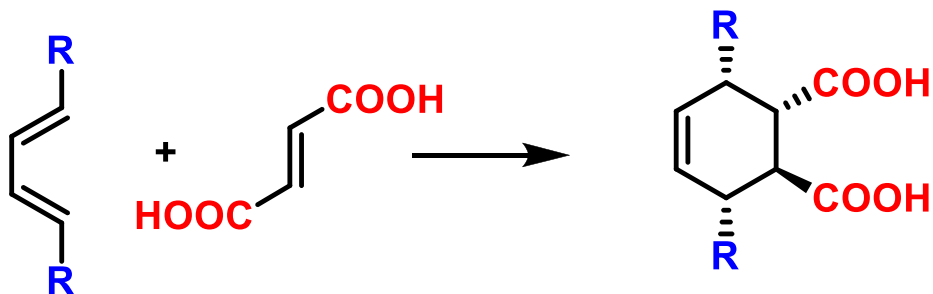
The Transition State



Another View



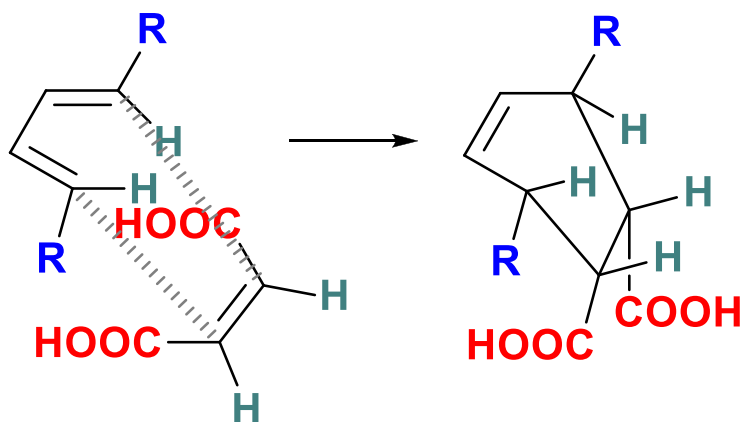
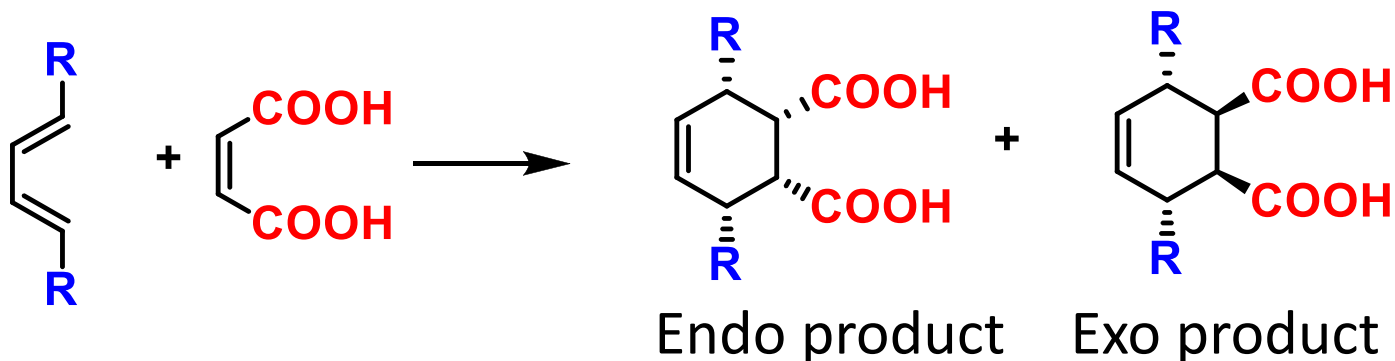
Diels Alder reaction – Highly Stereospecific



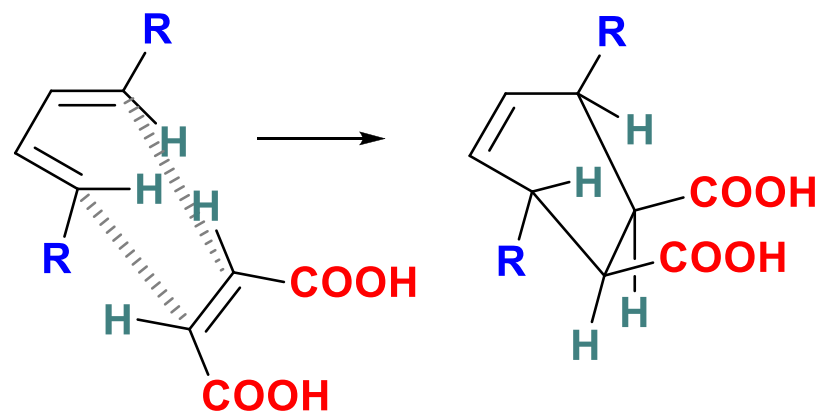
major product

Alder Endo Rule

Dienophile approaches the diene preferentially in the endo mode so as to allow maximum spatial overlap of the unsaturated centers of the diene and dienophile



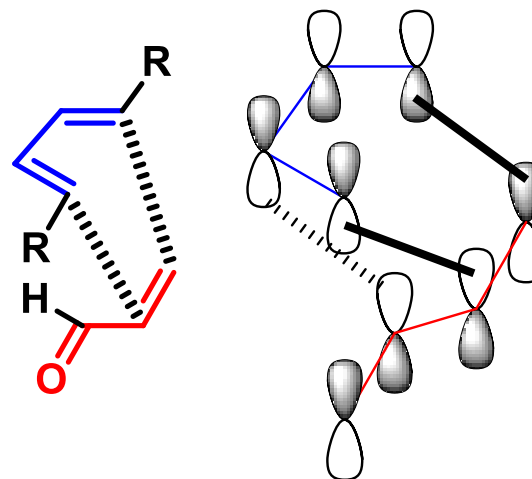
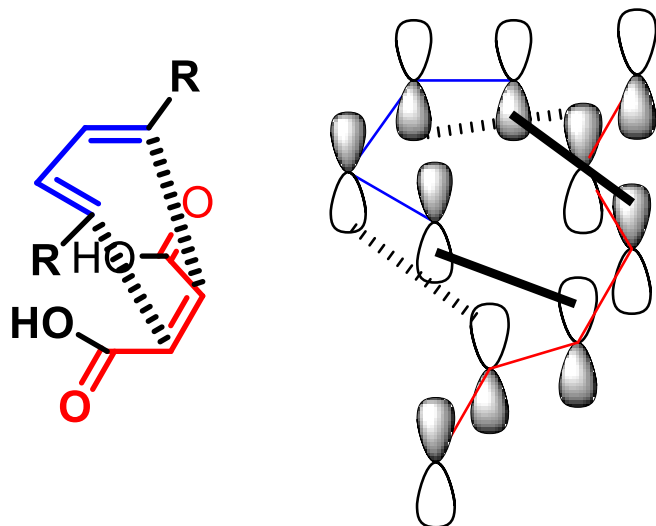
Endo approach - Favoured



Exo approach

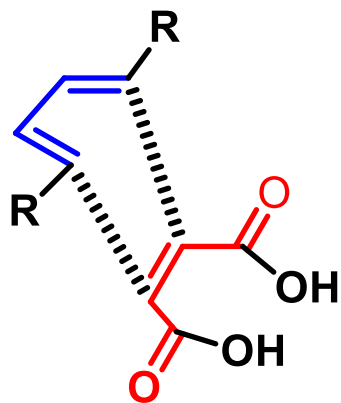
Why Endo Approach?

Endo Approach



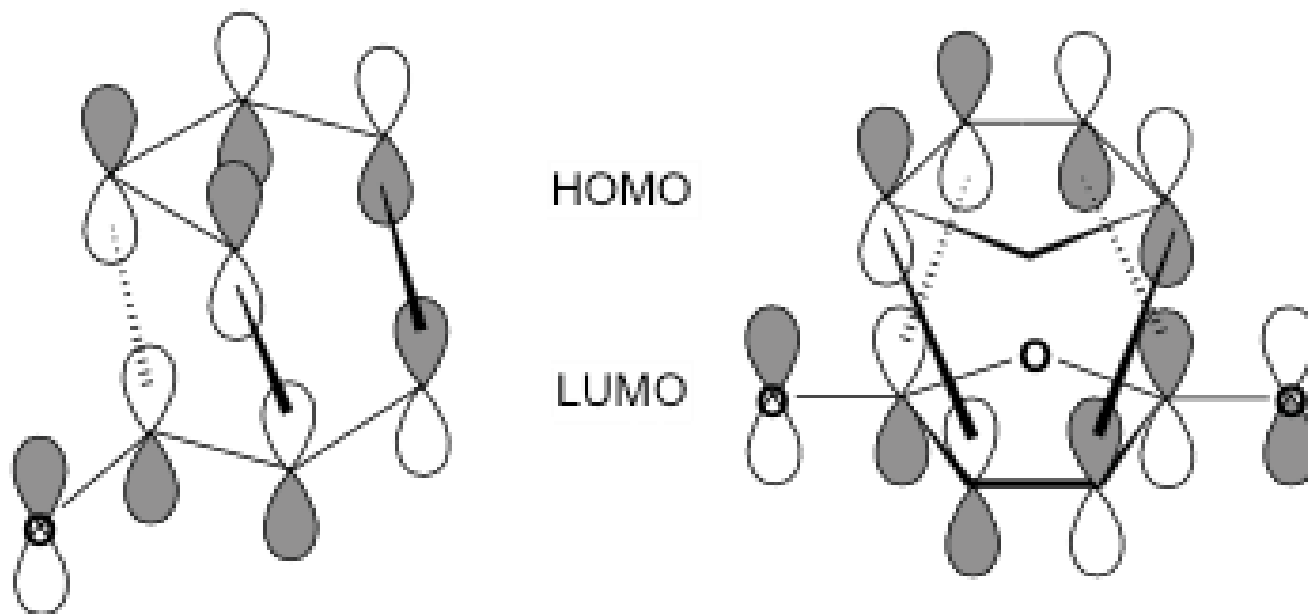
**Secondary Orbital Interactions
Transition State Stabilized!**

Exo Approach



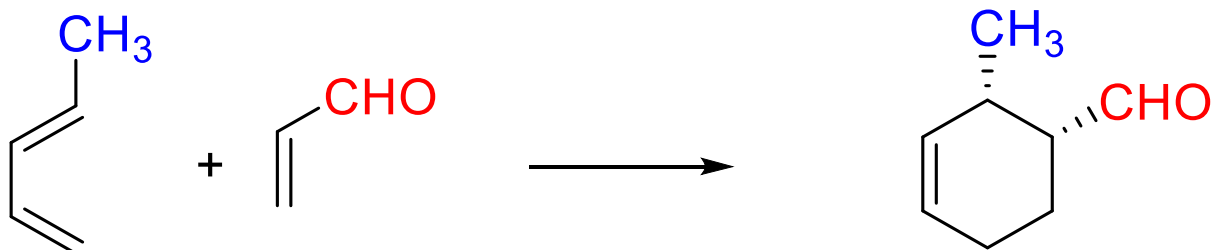
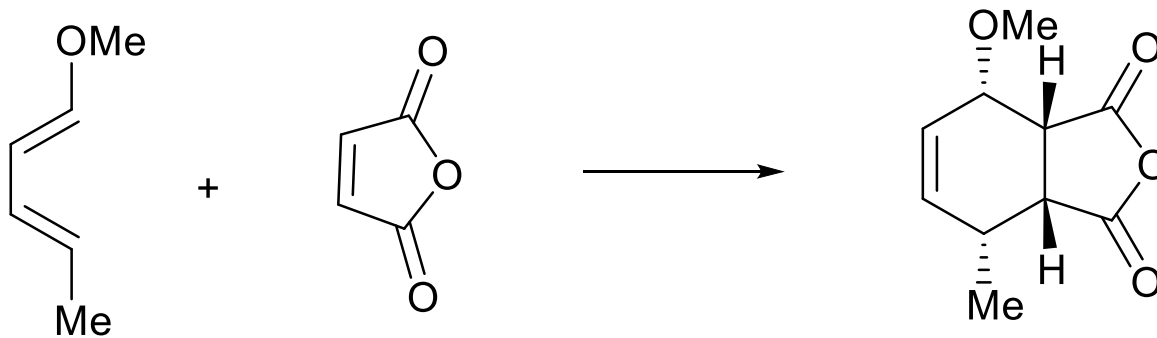
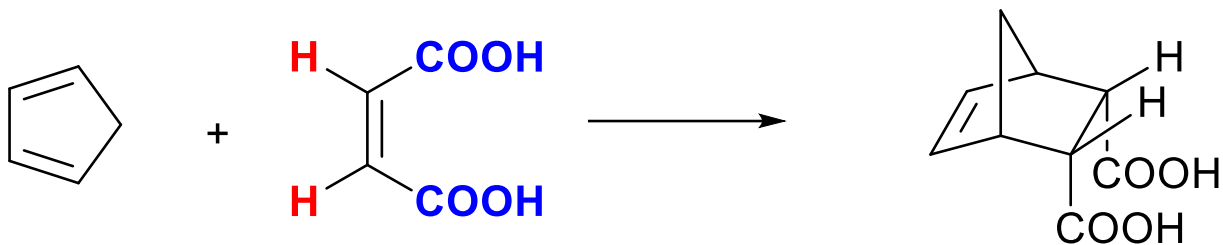
**Secondary Orbital Interactions difficult
(Orbitals far away from each other!)**

[4+2] Cycloaddition Reactions: The Alder Endo Rule

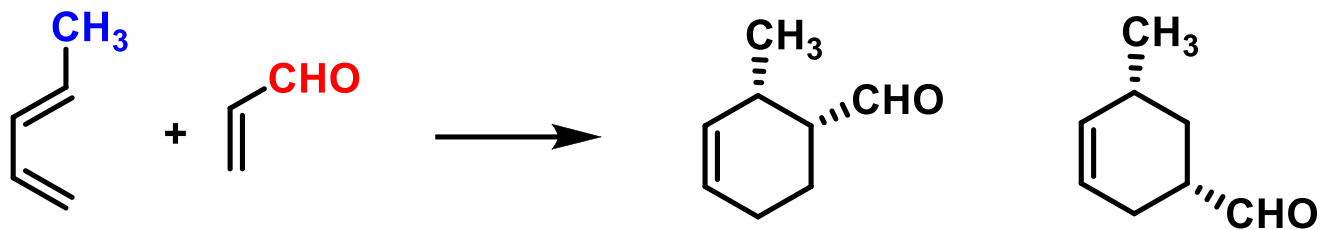


Excellent endo selectivity for maleic anhydride

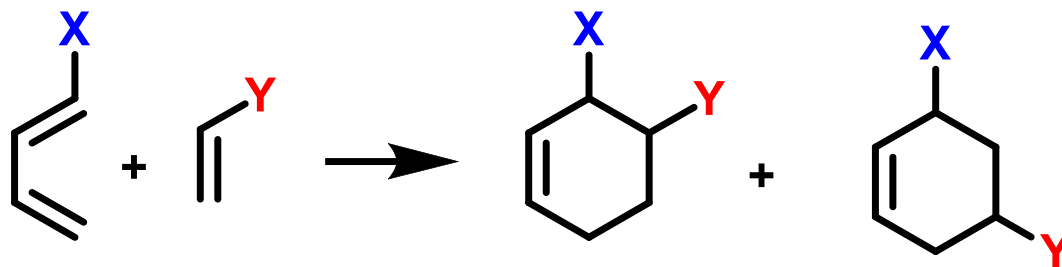
Let us try to write the products



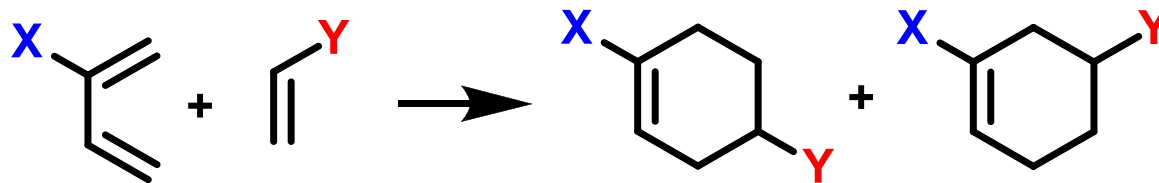
Regioselectivity



Major Product

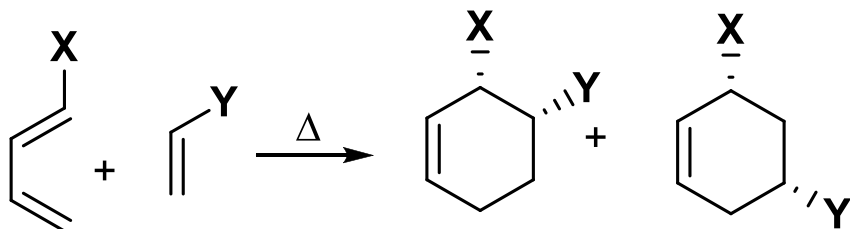


Favoured

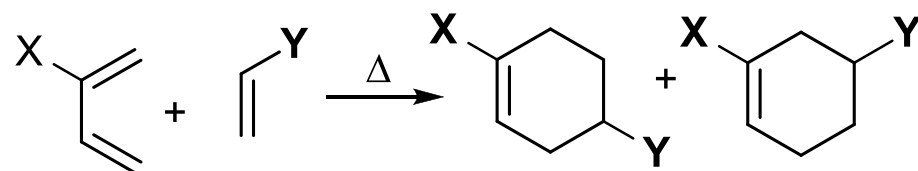


Favoured

Regioselectivity - Examples



X	Y	ortho	meta
Me	COOMe	89	11
OMe	COOMe	100	0
OMe	CN	100	0
OMe	CHO	100	0

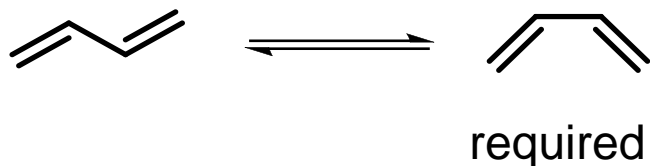


X	Y	para	meta
Me	COOMe	80	20
OMe	COMe	100	0
OMe	CHO	100	0
Ph	COOMe	80	20

Recap - $[4\pi + 2\pi]$ Cycloaddition

Reactivity

- S-Cis Conformation required

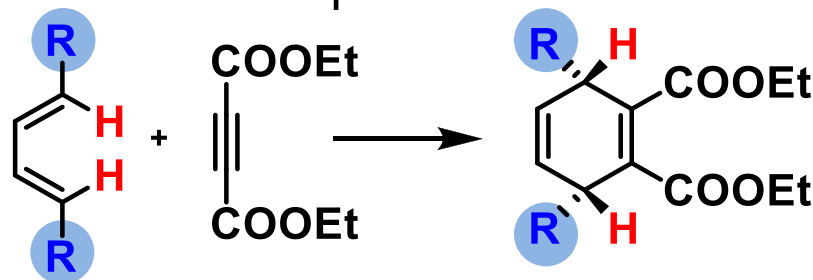


- ERG – Diene (HOMO)
EWG – Dienophile (LUMO)



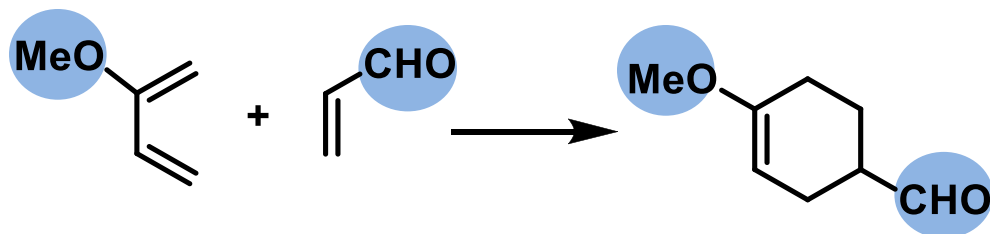
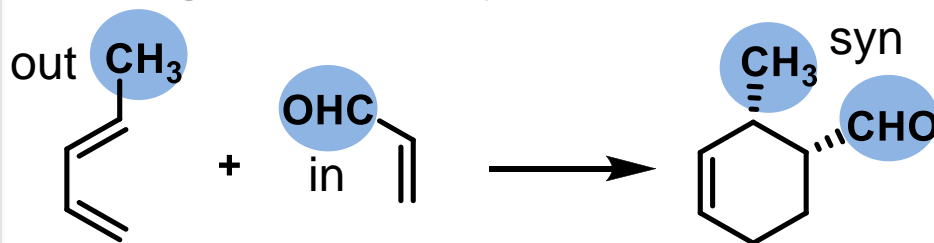
Selectivity

- Cis-rule** – Relative stereochem diene **or** dienophile

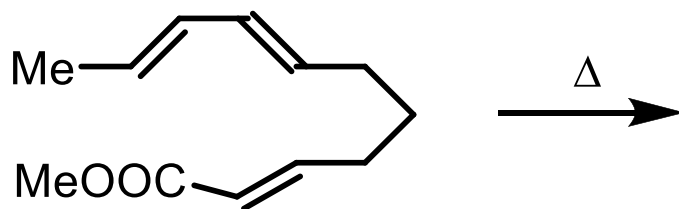


- Endo-rule** - Relative stereochem diene-dienophile

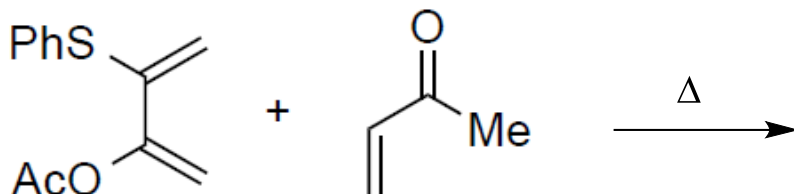
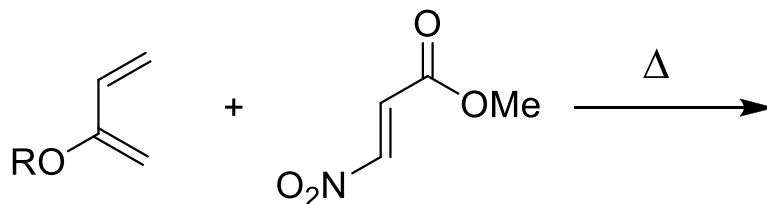
- Regioselectivity**



Problems for Practice



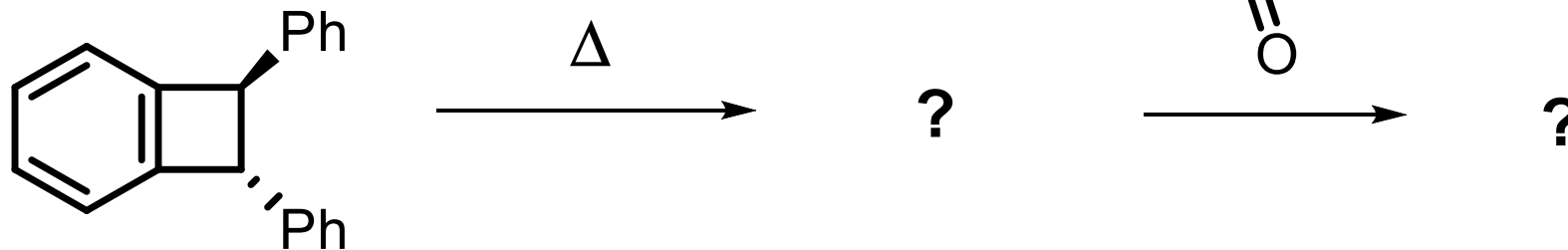
Intra-molecular



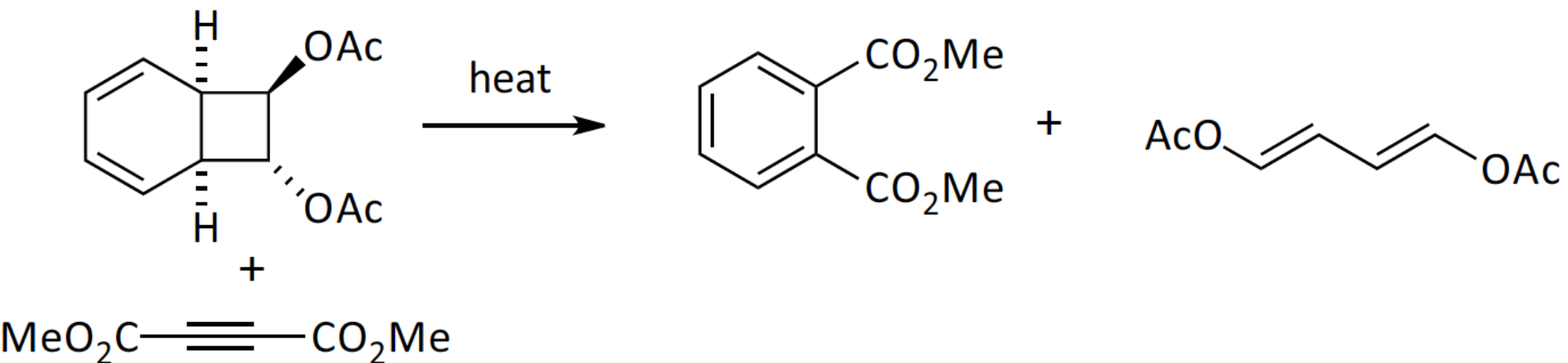
Don't get confused: Remember the basics ☺

More Problems

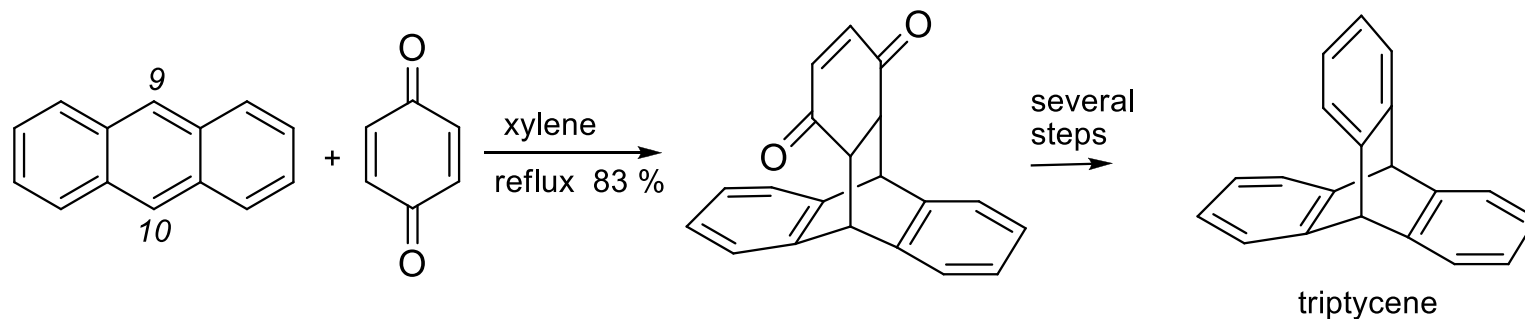
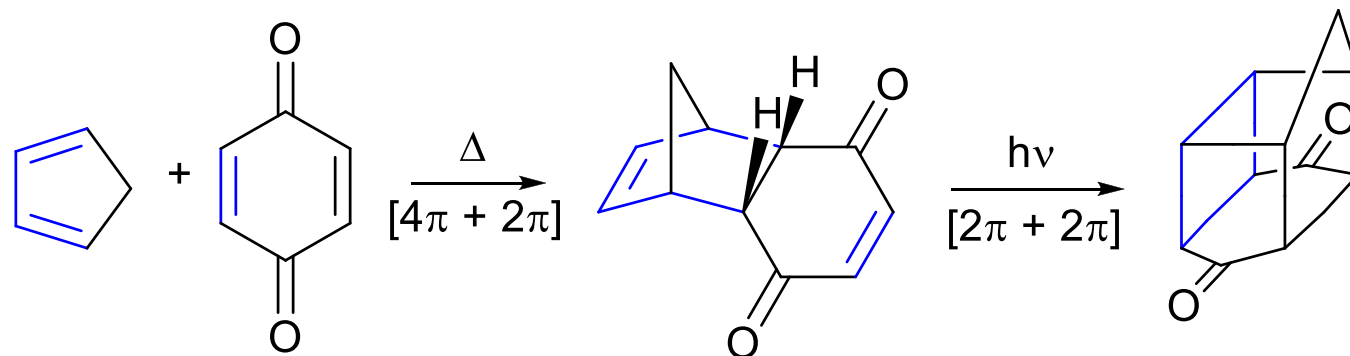
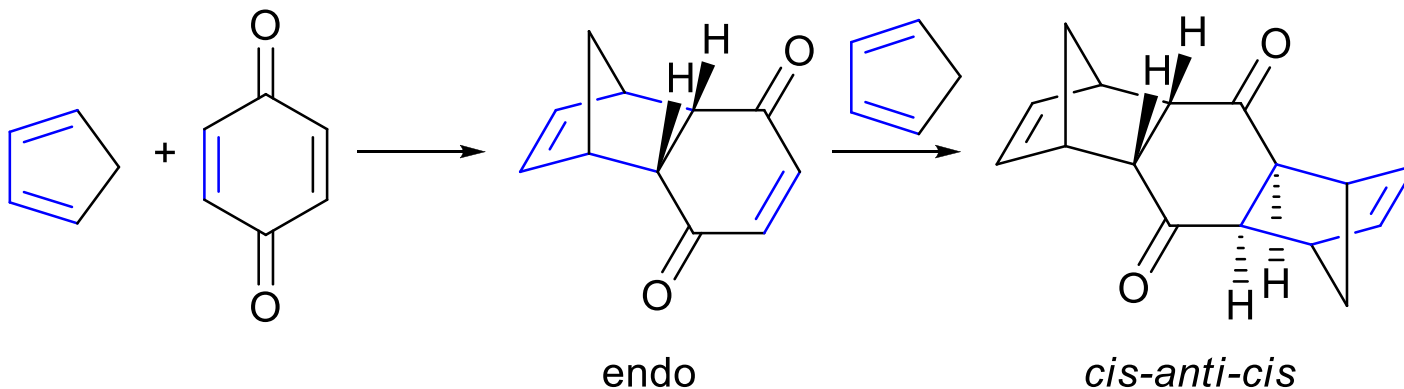
What is the product?



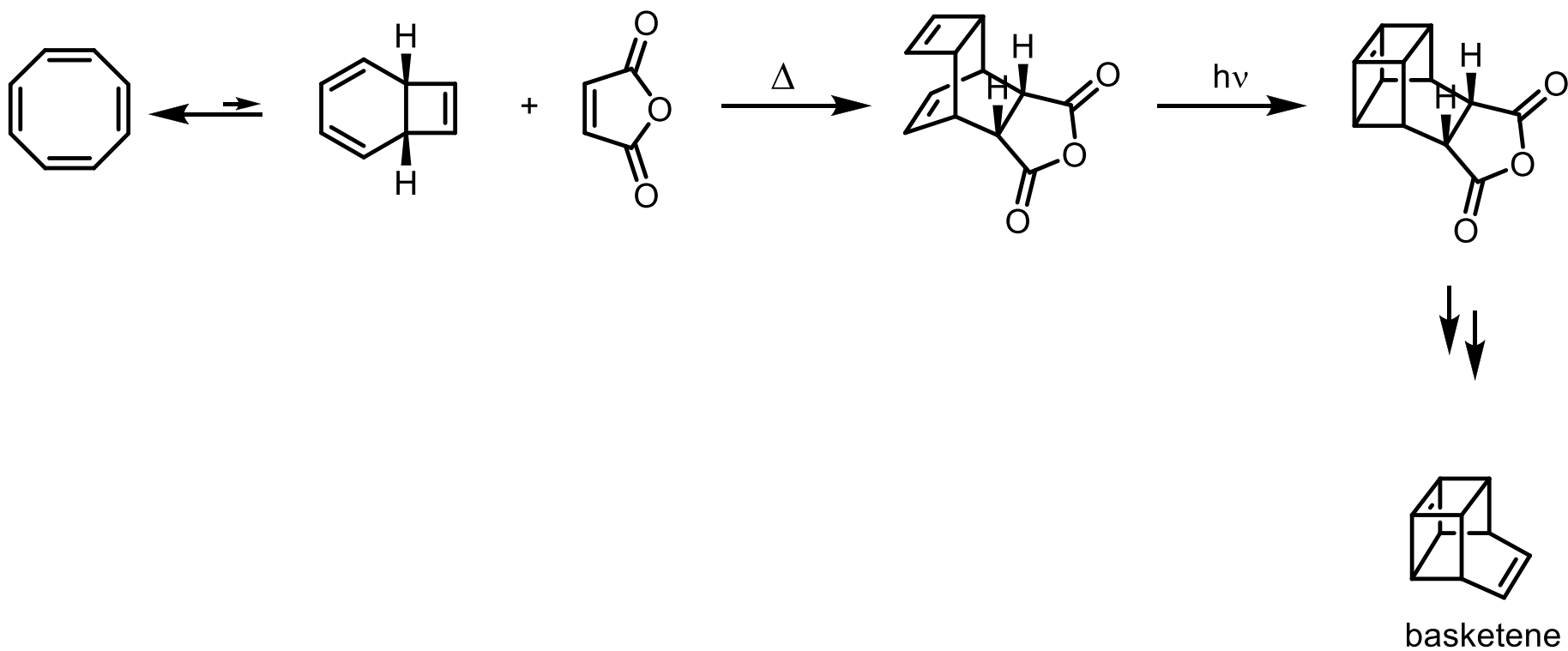
What is the mechanism?



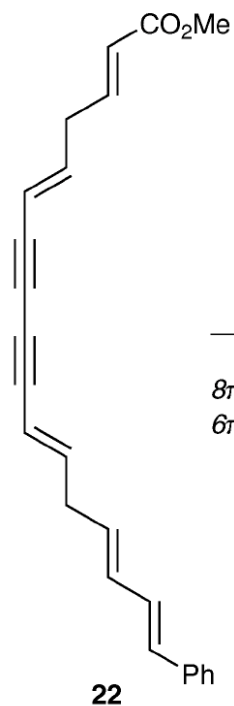
Synthetic Utility



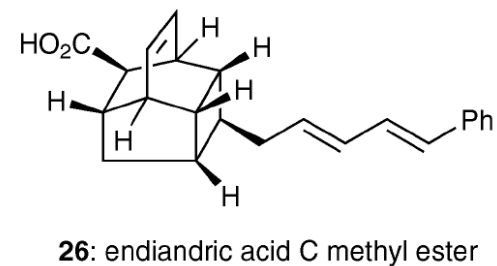
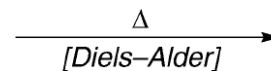
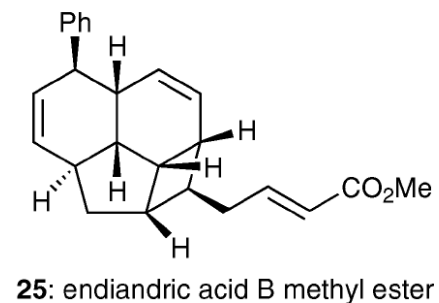
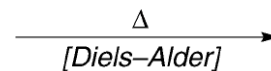
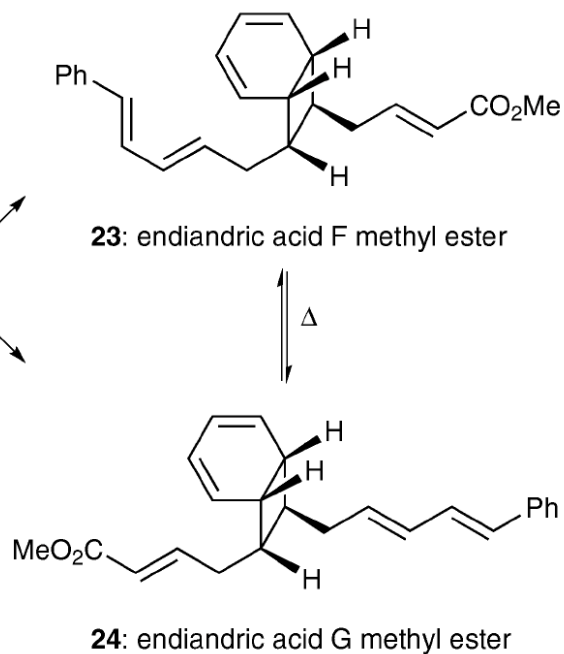
Synthesis of Basketene



Synthesis of Endiandric acid



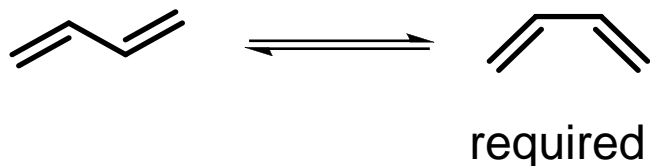
H_2 , Lindlar cat.
*[alkyne reductions,
 8π e electrocyclization,
 6π e electrocyclization]*



Recap - $[4\pi + 2\pi]$ Cycloaddition

Reactivity

- S-Cis Conformation required

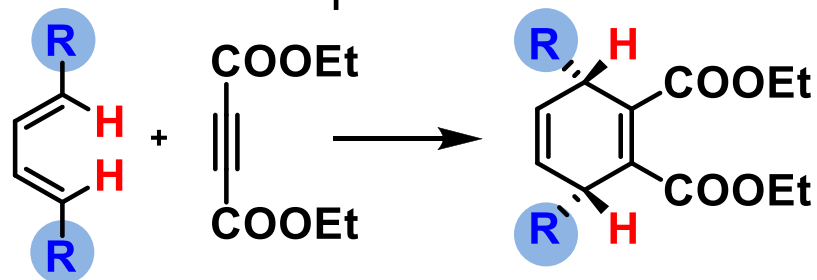


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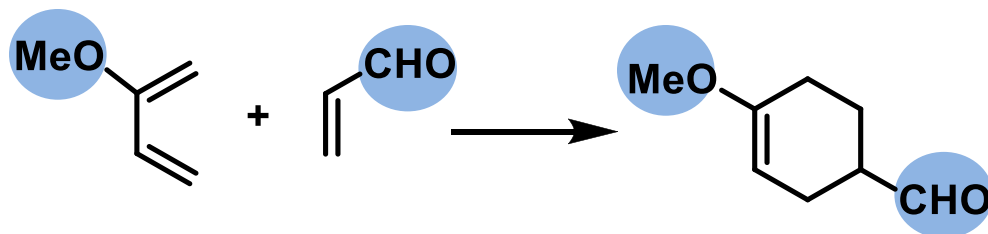
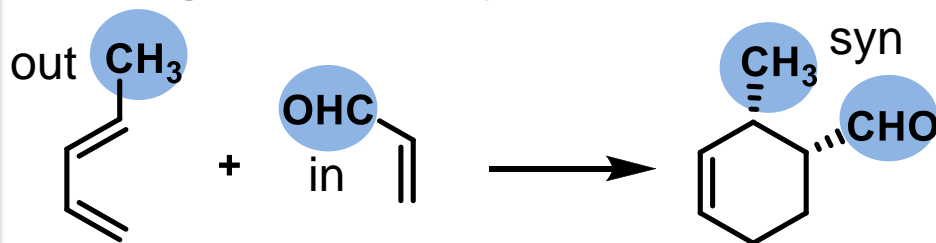
Selectivity

- Cis-rule** – Relative stereochem diene **or** dienophile



- Endo-rule** - Relative stereochem diene-dienophile

- Regioselectivity**

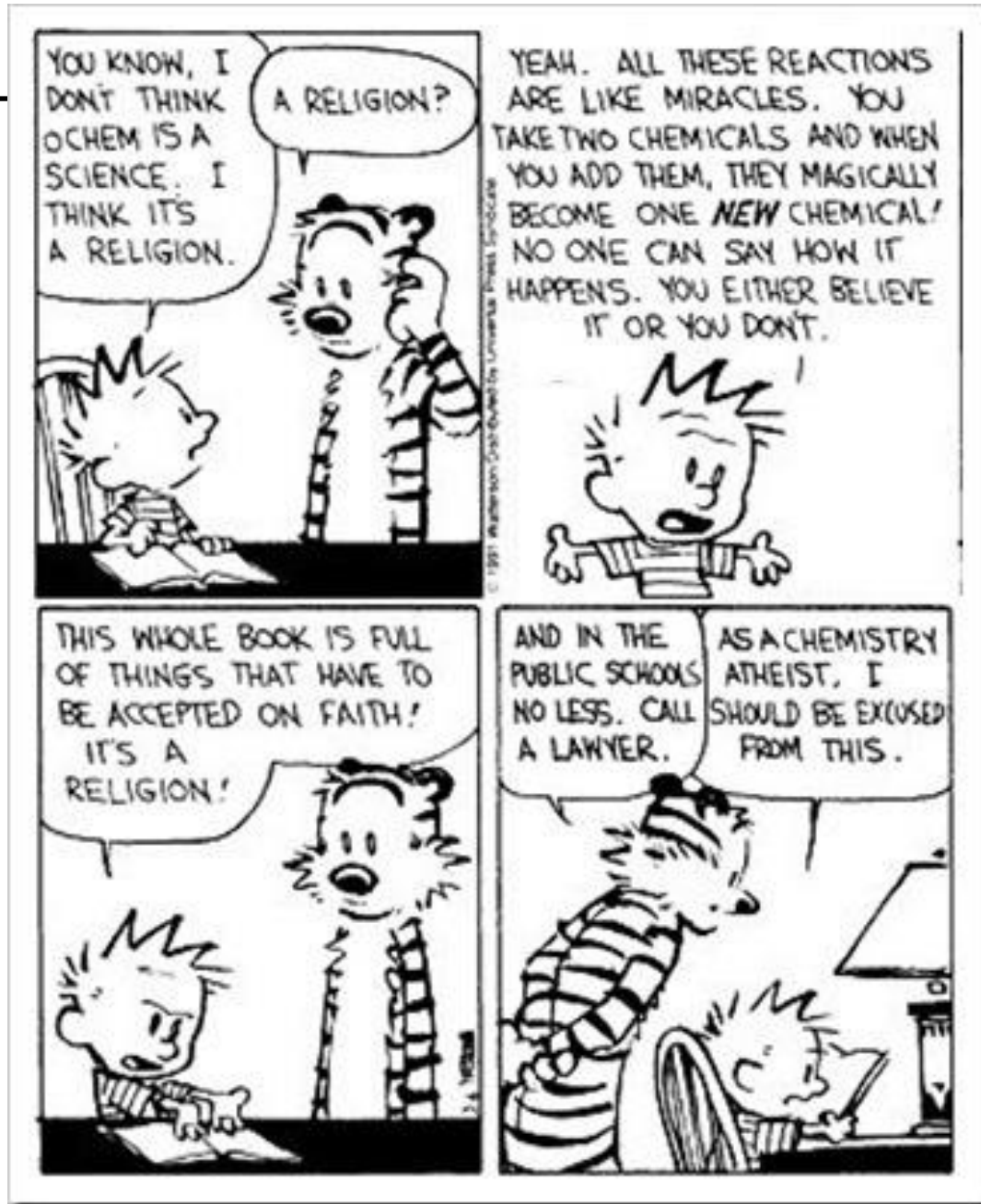


Final Exam

Mark your calendars for Final Organic Exam

November 26, 2022

9:30 – 11:30 am



Topics
covered
here quite
logical!!!

All the Best!!!!

Philosophy on teaching-learning and role
of a teacher beautifully captured here –

Enjoy !

<https://youtu.be/X7tHZaWP6DY>