

Spring 2023 Chem 12B Possible Bio or Industrial Reactions:

Chem 12B, Spring 2023 Bio/Industrial Reactions Project
Due Wednesday, 5/17/23 at noon.

Your Bio/Industrial Reactions assignment grade is based on two components:

1. Bio/Industrial Reactions Presentation = 75% for presentation content (12A reactions, structural features, mechanisms with curved arrows, other concepts correct). Each member of your group earns the same grade.

Submit (by e-mail or share via Google Drive) your Bio or Industrial Reactions Application presentation slides to me by Wednesday, 12/14/22 at noon.

I will post your slides on the Chem 12A web page.

2. Evaluation of two reactions in two different presentations = 25%.

You will evaluate and grade two reactions in two different presentations by Friday, 12/16/22 at noon.

You will work in a group of 2 to 4 to apply 2 or more Chem 12B reaction mechanisms to a Biology reaction or Industrial reaction.

The number of group members = number of different reaction mechanisms in your Biology reaction or Industrial reaction.

You and your group will prepare a presentation of each step of your Biology reaction or Industrial reaction.

Each person should present one reaction mechanism. Help each other and check each person's work.

Your Biology or Industrial Reaction must be **reaction types** we have covered in Chem 12B this semester.

For each reaction, identify the reaction type, structural features, and reactive sites, e.g., alpha carbon, describe the mechanism using curved arrows, and other concepts that are important in the reaction. Other concepts may include resonance structures and stability, formal charge, stereochemistry of reactants and products, regioselectivity.

To make sure your reactions are reactions we have covered in Chem 12B, submit your reactions on a Google form on the Chem 12B home page to me by 5/1/23 so I can review and approve your reactions.

Prepare your presentation on Google Slides – it makes it easy to share your presentation.

Draw your own structures and reactions by hand or with a chemical drawing software, e.g., Marvin Sketch or ChemDoodle. Do not copy a structure or reaction from a reference source.

Your Bio/Industrial Reactions assignment grade is based on two components:

1. Bio/Industrial Reactions Presentation = 75% for presentation content (12B reactions, structural features, mechanisms with curved arrows, other concepts correct). Each member of your group earns the same grade.

Submit (by e-mail or share via Google Drive) your Bio or Industrial Reactions Application presentation slides to me by Wednesday, 5/17/23 at noon.

I will post your slides on the Chem 12B web page.

2. Evaluation of two reactions in two different presentations = 25%.

You will evaluate and grade two reactions in two different presentations by Friday, 5/19/23 at noon.

Spring 2023 Chem 12B Possible Bio or Industrial reactions. Many of these reactions are shown in BACON, which you can do for lab extra credit.

1. Glycolysis: 10 steps. Each step is a Chem 12B reaction. You can describe the mechanism of each step except for Step 6 oxidation.

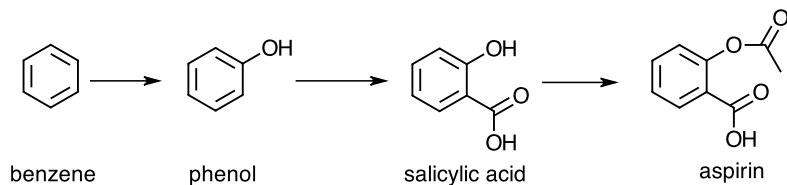
A group of 2, 3, or 4 can do 2, 3, or 4 steps of glycolysis, except Step 6.

2. pain reliever synthesis

a. Naproxen synthesis from 2-naphthol (see Chem 12B Objective 3 Ethers and Epoxides Slide 18)

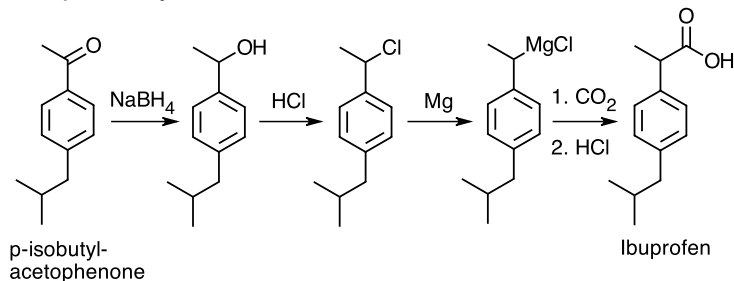
A group of 2 or 3 can do 2 or 3 steps of this synthesis.

b. aspirin synthesis from phenol or benzene



A group of 2 or 3 can do 2 or 3 steps of this synthesis.

c. Ibuprofen synthesis



A group of 2 or 3 can do 2 or 3 steps of this synthesis.

3. benzo[a]pyrene in cigarette smoke – how it alkylates DNA (see Chem 12B Objective 3 Ethers and Epoxides Slide 21)

A group of 2 or 3 can do 2 or 3 steps of this reaction.

4. epoxy glues from diol and epichlorohydrin (epoxide) (see Chem 12B Objective 3 Ethers and Epoxides Slide 30)

A group of 2 or 3 can do 2 or 3 steps of this reaction.

5. Lasalocid A antibiotic

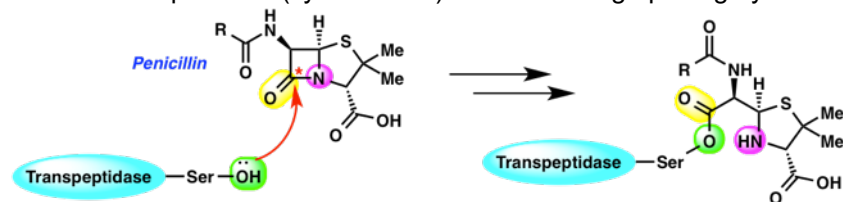
a. Bisepoxylasalocid A --> Lasalocid A by epoxide-opening cyclization (see Chem 12B Objective 3 Ethers and Epoxides Slide 33 and <https://cen.acs.org/articles/90/i10/Unfavored-Ring-Route-Revealed.html>).

b. Bisepoxylasalocid A --> another product by epoxide-opening cyclization. See last reaction sequence in <https://www.organic-chemistry.org/Highlights/2009/13April.shtm>

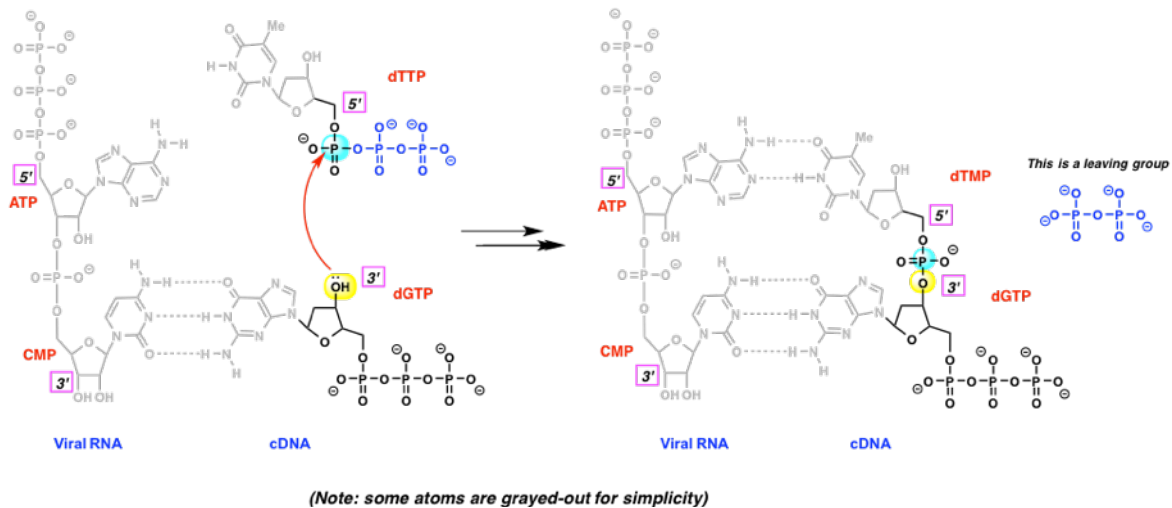
A group of 2 can do these 2 reactions.

6. How does penicillin work? It irreversibly inactivates transpeptidase enzyme which interferes with synthesis of peptidoglycan.

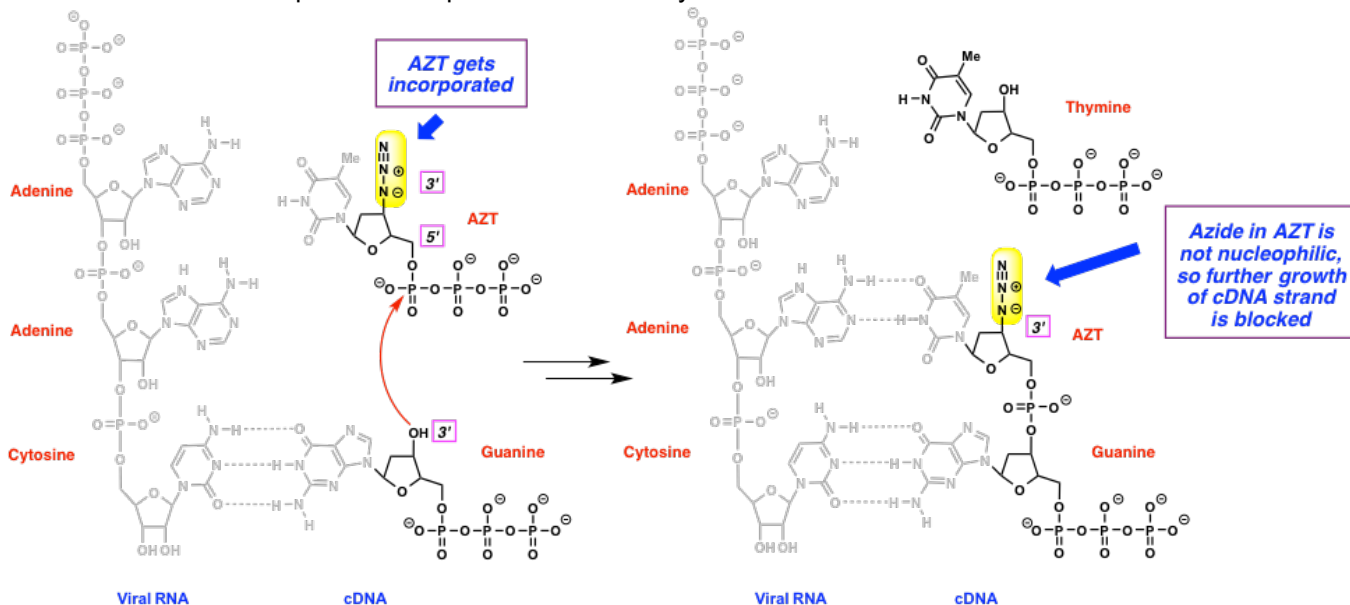
Penicillin is a β-lactam (cyclic amide) + ROH --> ring opening by nucleophilic acyl substitution



7. Reverse transcription – ID nucleophile and electrophile. Substitution reaction.



8. AZT, which is a thymine analog, has a azide group at the 3' end instead of an OH group. This slight modification shuts down reverse transcription and prevents the synthesis of a full cDNA strand. Chemically this occurs because AZT is readily incorporated into a growing strand of cDNA; however, subsequent growth of cDNA is not possible because the 3' end of AZT is not nucleophilic. HIV replication is ultimately hindered.



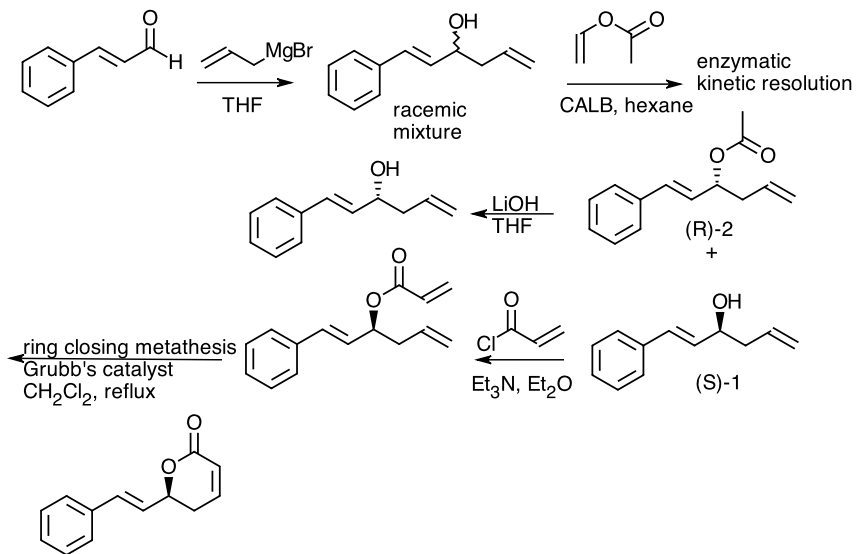
A group of 2 or 3 can do a combination of Reactions (6), (7), and (8).

9. cancer drugs

a. Tamoxifen (cancer drug) synthesis involves EAS, enolate ion, ether to alcohol, Nu:⁻ substitution, Grignard reaction, and elimination (see https://www.ch.ic.ac.uk/local/projects/h_tanner/snyth1.html)

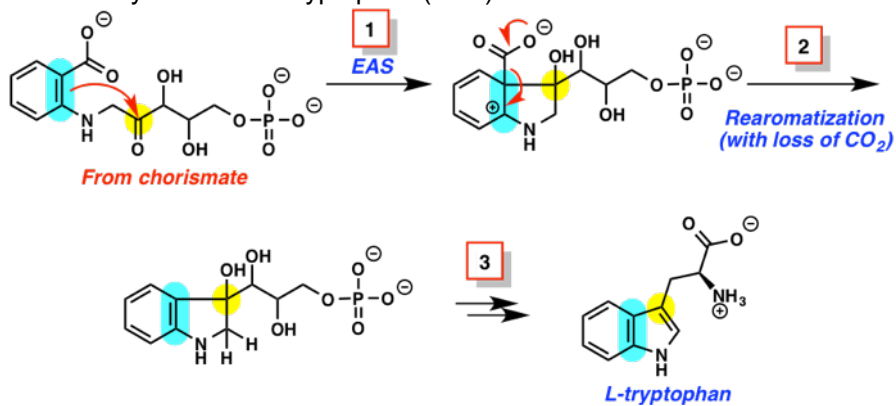
A group of 2 or 3 or 4 can do a combination of 2 or 3 or 4 steps in this reaction sequence.

b. Goniotalamin (antiproliferative activity against cancer cells) synthesis involves Grignard reaction and nucleophilic acyl substitution (Nahra and Riant, J. Chem. Educ., 2015, **92**, 179-182).

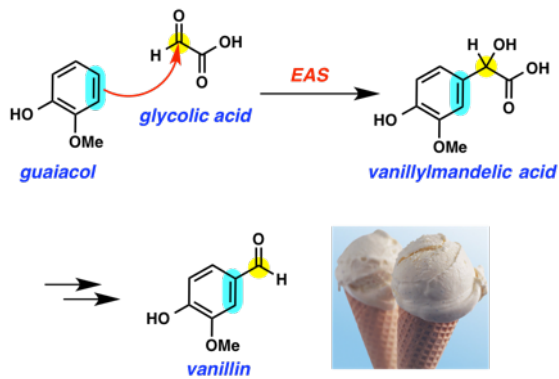


A group of 2 or 3 or 4 can do a combination of 2 or 3 or 4 steps in this reaction sequence.

10. a. biosynthesis of L-tryptophan (EAS)

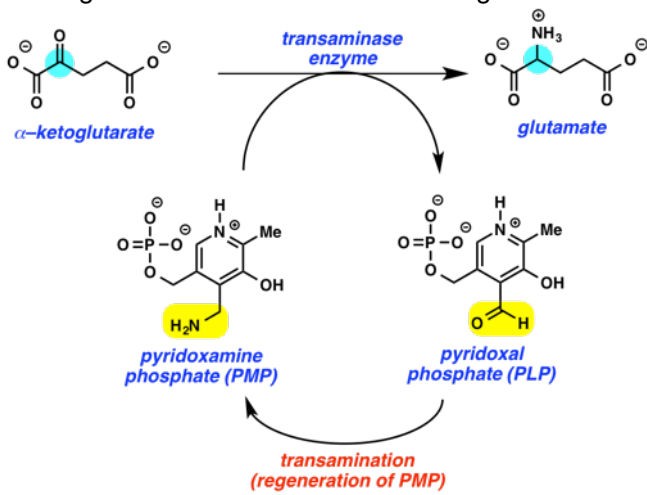


b. Guaiacol is present in wood smoke, resulting from the pyrolysis of lignin.



c. Iodine is an essential nutrient. Iodine deficiency leads to goiter, which occurs because thyroxine (thyroid hormone) cannot be generated without iodine.

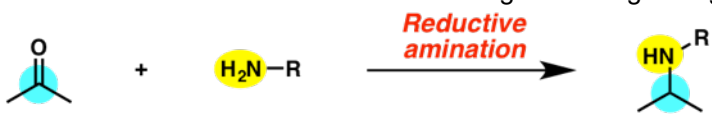
b. Once PMP forms, it converts alpha-ketoglutarate to glutamate (ketone to amine transamination process). This process is used in synthesis of glutamine and in glucose metabolism. α -ketoglutarate condenses with PMP to give an iminium ion intermediate. Draw the structure of this intermediate.



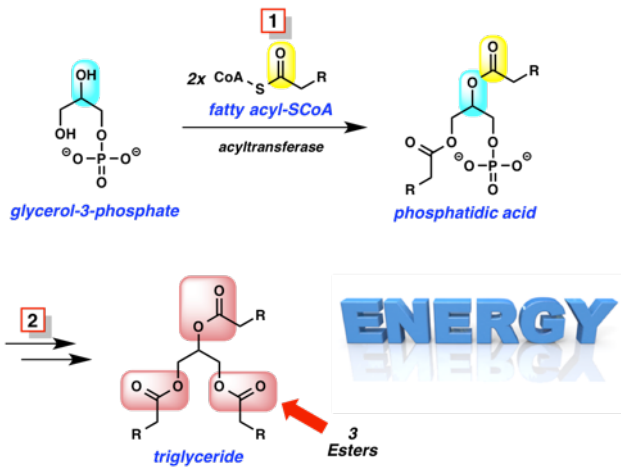
Excess glutamate has been associated with amyotrophic lateral sclerosis (ALS).

A group of 2 or 3 or 4 can do a combination of 2 or 3 or 4 of Reactions 11a and b (forward and reverse).

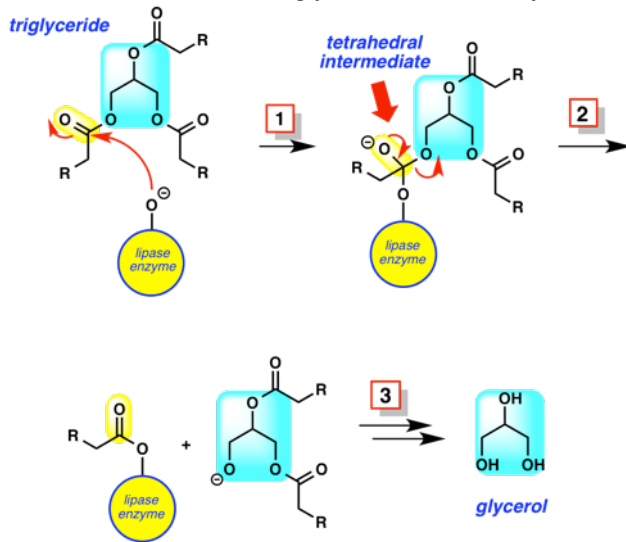
12. Reductive amination is used to make legal and illegal drugs, including methamphetamine. See Breaking Bad.



13. a. Triglyceride biosynthesis:

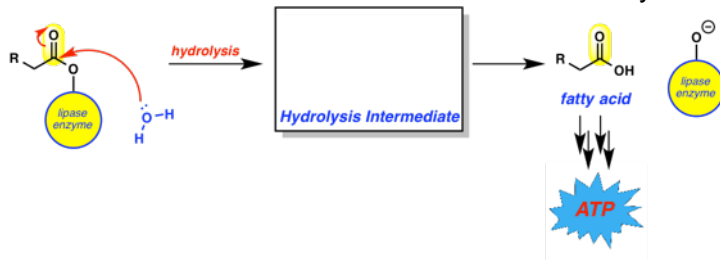


b. Reverse reaction - Triglycerides make fatty acids:



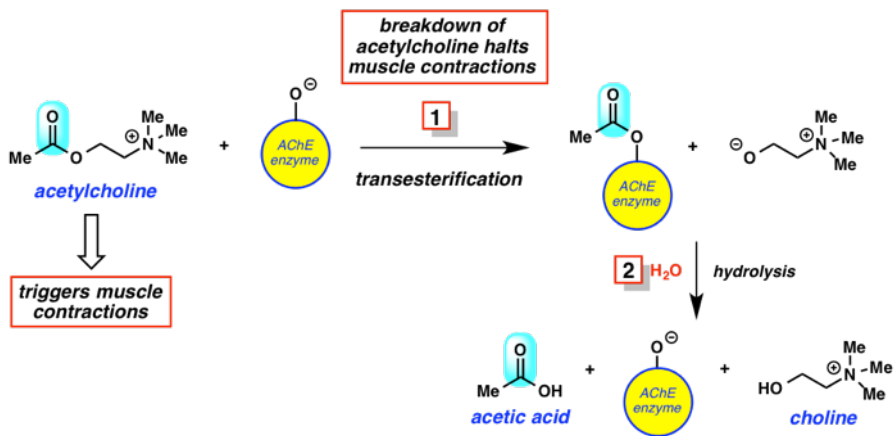
c. What happened to the fatty acid piece and where is the energy?

Predict the structure of the intermediate formed initially after attack of the water onto the enzyme bound ester.



A group of 2 or 3 can do a combination of 2 or 3 of Reactions 13a, b, and c.

14. a. Acetylcholine (neurotransmitter) is an ester. In the peripheral nervous system, acetylcholine binds to its corresponding receptors in muscle fibers to open sodium channels. This causes muscles to contract. A transesterification reaction is involved in the process of stopping a muscle contraction. (AChE = acetylcholinesterase enzyme)

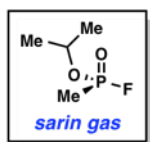


A group of 2 can do these 2 reactions.

b. Chemical warfare and esters.

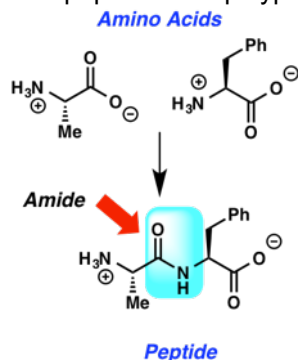
Phosphate ester is found in our body – contains P atom in place of the carbonyl C.

Phosphate ester – sarin nerve gas. How does it work? Phosphate ester of sarin gas can be attacked by AChE enzyme and disables the AChE enzyme and prevents the necessary metabolism of acetylcholine in our body. Without muscle control in breathing, asphyxia occurs --> death.



A group of 3 can do the reactions in 14a and b.

15. Amides are one of the most important and prevalent functional groups in biology and medicine. See peptides and polypeptides.



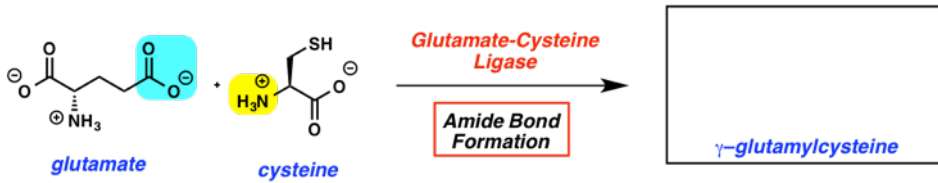
Robert B. Merrifield

July 15, 1921
to May 14, 2006

1984 Nobel Prize in Chemistry:
"for his development of
methodology for chemical
synthesis on a solid matrix."

Glutathione (antioxidant found in plants, animals, and fungi) synthesis.

Predict the structure of the amide product γ -glutamylcysteine that is formed after coupling of glutamate and cysteine.



GLUTATHIONE BENEFITS

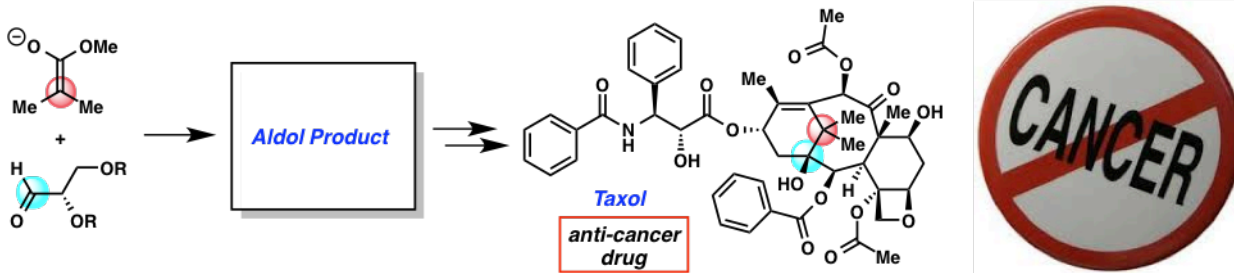
- Increases energy
- Slows down the aging process
- Reduces muscle & joint discomfort
- Strengthens immune system
- Detoxifies the liver & cells
- Improves mental focus & clarity
- Improves quality of sleep
- Reduces the effects of stress
- Improves the skin
- Athletic performance & recovery

A group of 2 can do this reaction to glutathione.
 A group of 3 can do the reaction to glutathione and the reverse of one reaction.

16. Ketones and aldehydes undergo the aldol reaction. Enzymes catalyze the aldol or reverse (retro-aldol).
 a. indigo synthesis in 1880



b. Taxol (anti-cancer drug) synthesis uses 5 aldol reactions. Predict product of 1st aldol reaction:



A group of 2 can do these 2 reactions.