

## Fall 2022 Chem 12A Possible Bio or Industrial Reactions:

Due Wednesday, 12/14/22 at noon.

You will work in a group of 2 to 4 to apply 2 or more Chem 12A 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 12A 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 12A, submit your reactions on a Google form on the Chem 12A home page to me by 11/28/22 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 (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.

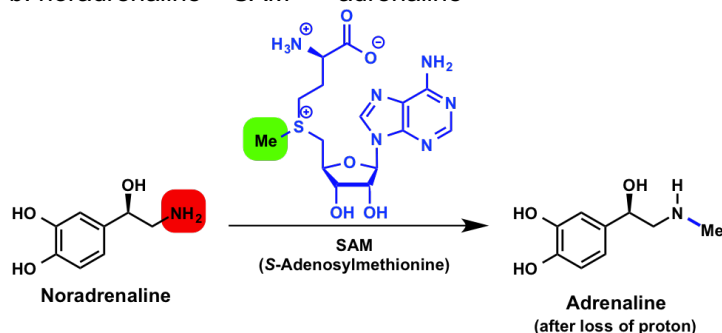
Here are some possible biology and industrial reactions. Many of these reactions are shown in the BACON extra credit assignment.

### SUBSTITUTION REACTIONS

1. Adrenaline from methionine and ATP: See Chem 12A Objective 9 Lecture Slides 22 and 23.

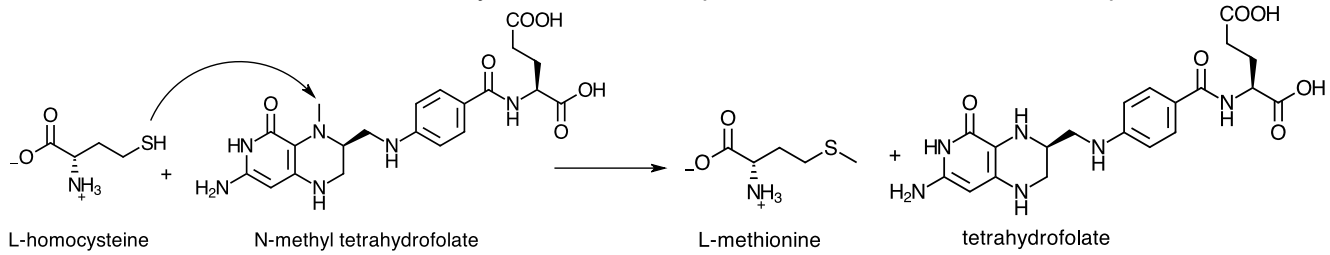
a. methionine + ATP --> SAM

b. noradrenaline + SAM --> adrenaline



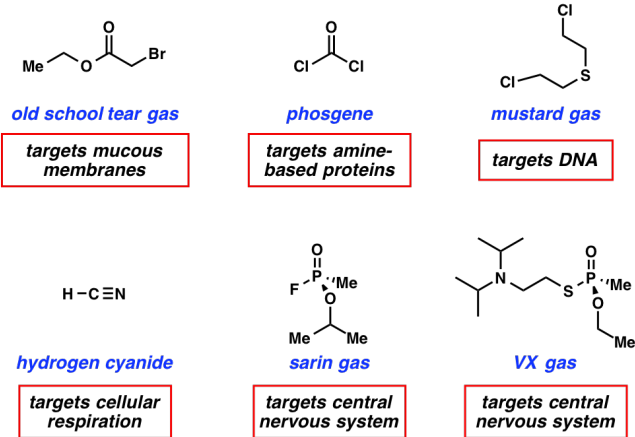
Note: We reviewed these reactions in Chem 12A lecture during Week 9. If you and your group choose these reactions, you and your group can look at the other possible products of each reaction and explain which product is the major product. A group of 2 can do these 2 reactions.

2. Methionine is the most common eukaryote start codon in process of translation of mRNA to protein.

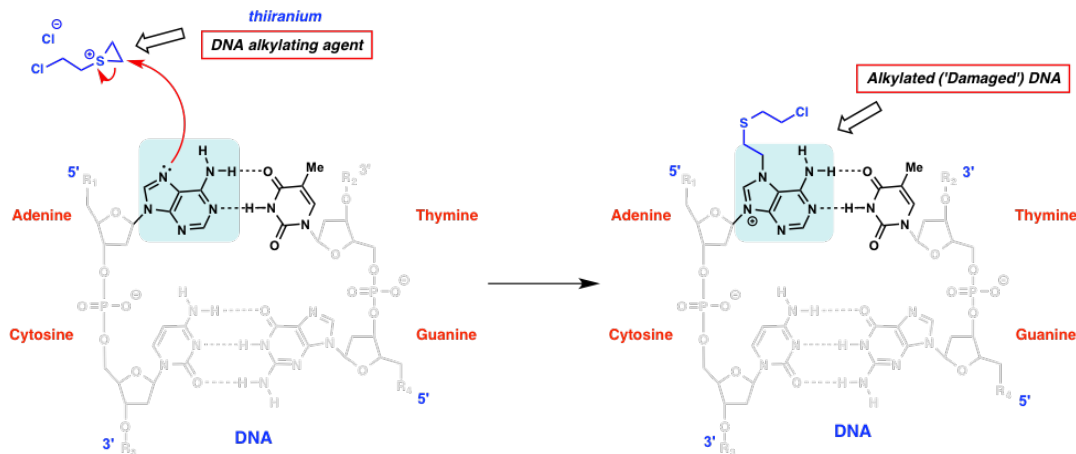
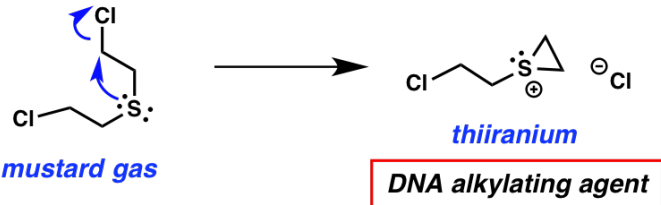


Note: a group of 3 can do this reaction and the reactions in (1) – how are these 3 reactions related?

3. Chemical warfare and substitution reactions



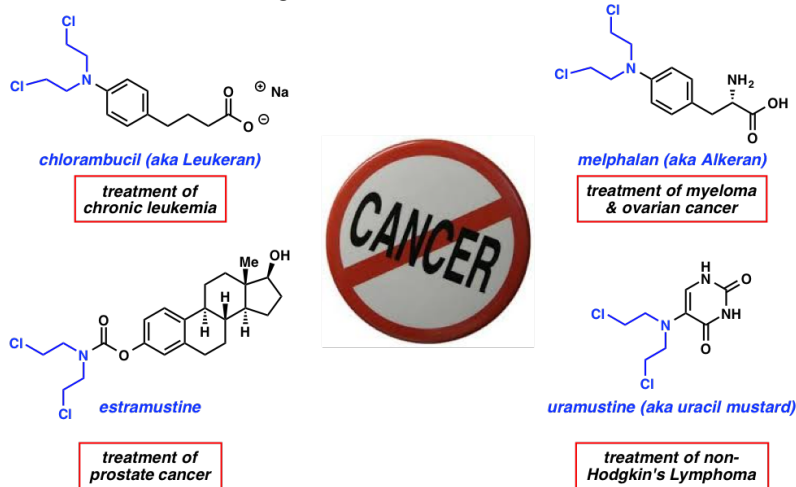
S<sub>N</sub>2 reaction:



Note: a group of 2 can do these 2 reactions. Look at other possible products of this reaction and explain which product is the major product.

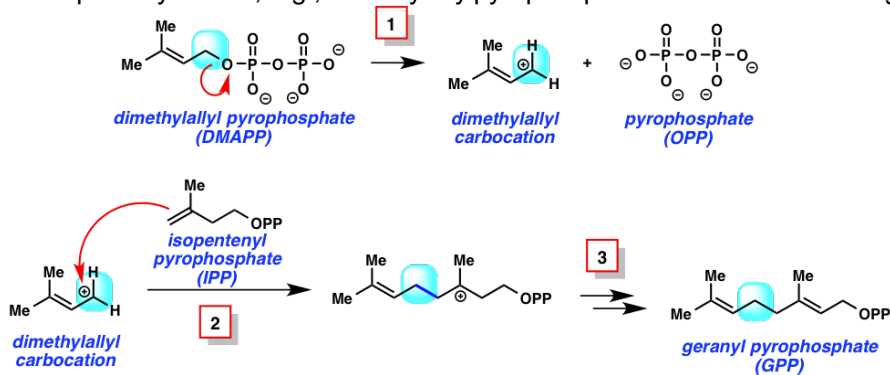
4. Nitrogen mustard (analog of sulfur mustard) used as cancer treatment.

Nitrogen mustard derivatives, e.g., chlorambucil, melphalan, estramustine, uramustine, are anti-cancer drugs, which reacts with DNA leading to death of cancer cells but with undesirable side effects.



Note: a group of 3 can do this reaction (how nitrogen mustard reacts with DNA) and the reactions in (3).

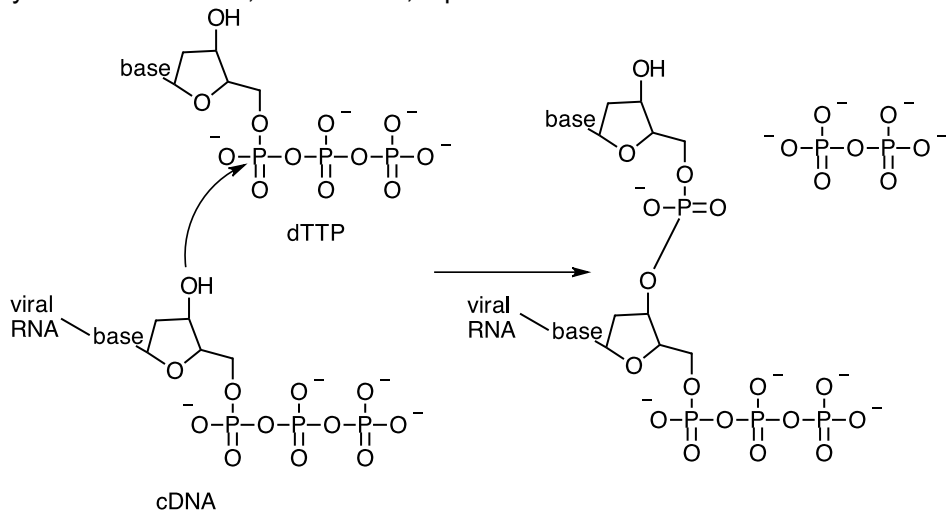
5. Terpene synthesis, e.g., dimethylallylpyrophosphate is used as a building block to form GPP.



Note: a group of 2 can do these 2 reactions. Reactions 1 and 2 show the steps of the mechanism for one reaction. Reaction 3 shows how a carbocation forms an alkene.

6. Preview of a Chem 12B reaction: the reaction shown below is a nucleophilic acyl substitution reaction.

Reverse transcription is the process that generates complementary DNA from an RNA template. It is an essential process by which retroviruses, such as HIV, replicate.

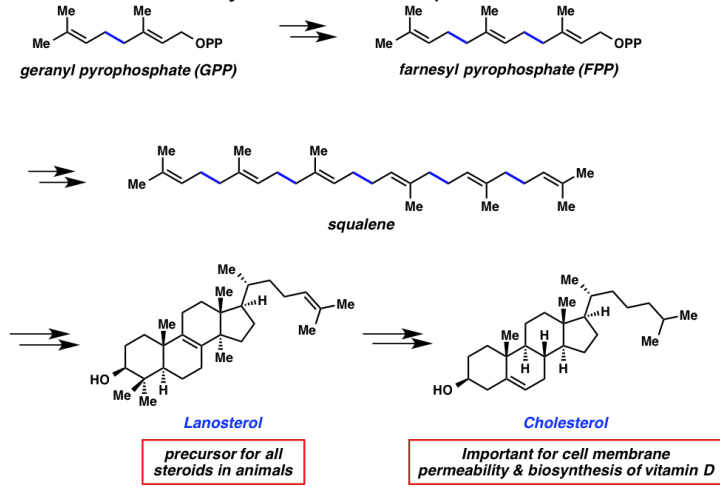


AZT is a drug that inhibits reverse transcription. The OH group is replaced with azide group. Azide group is not nucleophilic and will not undergo substitution at P.

## ELIMINATION REACTIONS

7. GPP → FPP → squalene → lanosterol

See Chem 12A Objective 12 Electrophilic Addition last three slides – squalene to lanosterol.



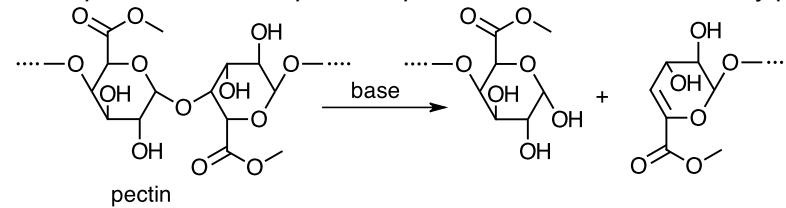
Note: a group of 2 or 3 can do the squalene to lanosterol reaction: this series of reactions involve addition, rearrangement, and elimination reactions.

8. How baking soda cooks some foods (oven roasted fries, carrot cake, caramelized onions, polenta) faster.



Heating baking soda increases alkalinity because \_\_\_\_\_. Hint: compare the base strength of  $\text{Na}_2\text{CO}_3$  and  $\text{NaHCO}_3$ .

The rapid breakdown of pectin at pH > 5-6 weakens cell walls by  $\beta$ -elimination reaction to form an alkene.

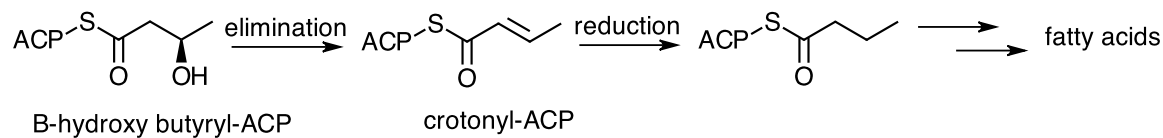


Note: a group of 2 can do this reaction. 1<sup>st</sup> reaction is the forward reaction and the 2<sup>nd</sup> reaction is the reverse reaction.

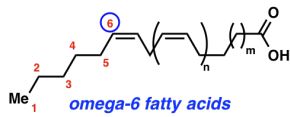
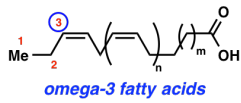
9. Fatty acids – palmitic acid (saturated) and oleic acid (unsaturated). Nature makes them from common intermediates.

Fatty acid biosynthesis

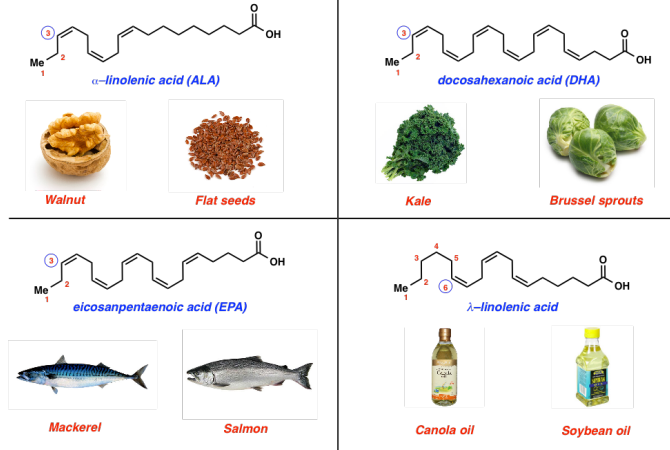
$\beta$ -hydroxy butyryl-ACP → elimination → crotonyl-ACP → reduction → → → fatty acids



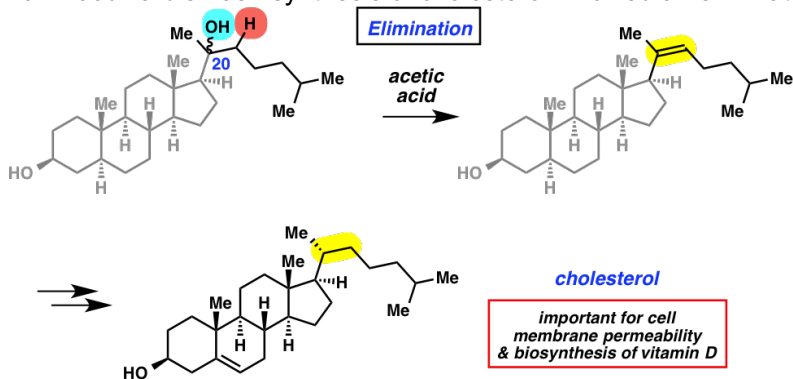
An elimination reaction occurs. The other possible product is \_\_\_\_\_. Crotonyl-ACP is the major product because \_\_\_\_\_. Omega-3 and omega-6 fatty acids refer to the location of the C=C bond from the terminal end of the fat.



Omega-3 and omega-6 fatty acids common sources:

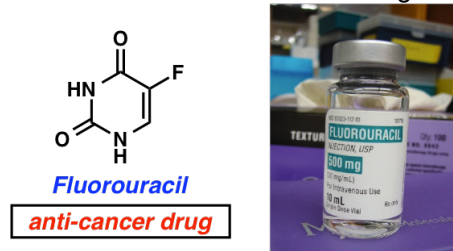


10. Woodward's 1952 synthesis of cholesterol involved an elimination reaction:

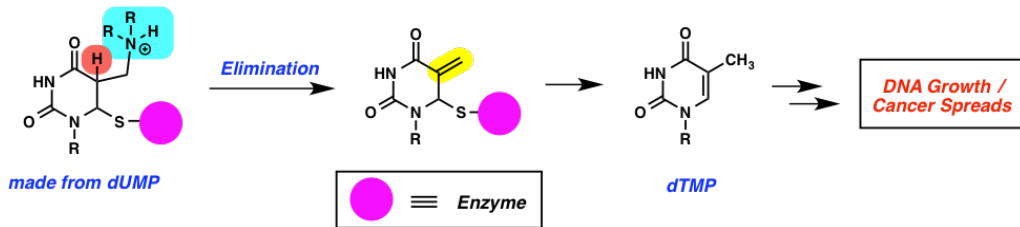


An elimination reaction occurs. The other possible product is \_\_\_\_\_. The major product is \_\_\_\_\_ because \_\_\_\_\_.  
**Note: a group of 2 can do the Reaction (9) and (10) – these are reactions involving fats.**

11. Fluorouracil – anti-cancer drug. Mechanism of action is an elimination reaction.



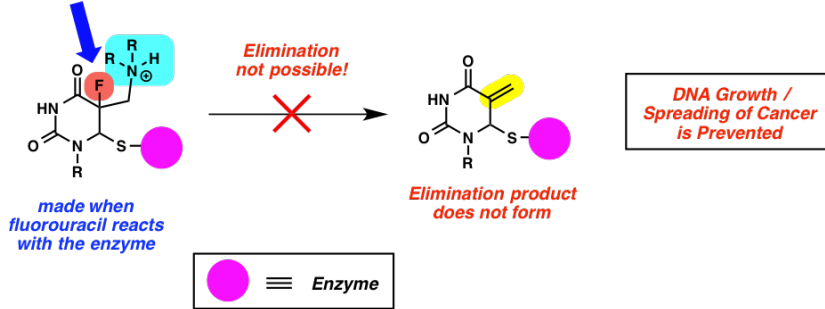
How a cancer cell divides:



thymidylate synthase converts deoxyuridinemonophosphate (dUMP) to deoxythymidinemonophosphate (dTMP). One step is an elimination reaction. The other possible product is \_\_\_\_\_. The major product is \_\_\_\_\_ because \_\_\_\_\_.

Fluorouracil is an anti-cancer drug (breast, skin, stomach, pancreatic, colon cancers). How does fluorouracil work? Replace H by F and no elimination reaction.

*F instead of H  
(need H adjacent to leaving group for elimination)*

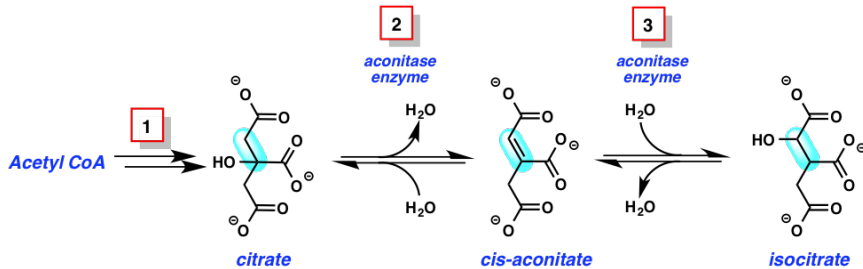


Note: a group of 2 can do the "how a cancer cell divides" reaction. 1<sup>st</sup> reaction is the elimination reaction. 2<sup>nd</sup> reaction is the elimination product --> dTMP.

## ADDITION REACTIONS

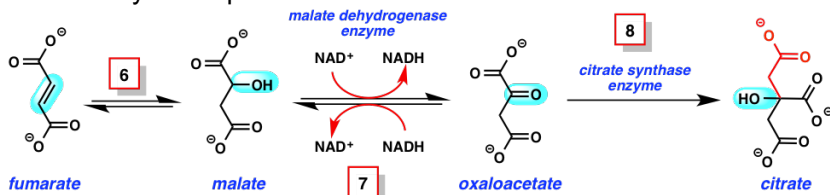
12. Kreb's cycle:

a. how would you classify Step 3? (anti-Markovnikov addition) What reaction conditions are needed for this product to form?




Note: a group of 2 can do Steps 2 and 3.

b. Kreb's cycle Steps 6-8:




Note: a group of 3 can do Steps 2, 3, and 6.

Beautiful Mind movie: dehydration prevents the Kreb's cycle from functioning effectively after a night-out (hangover).




**1979 Nobel Prize in Chemistry**  
May 22, 1912 – December 19, 2004

**H. C. Brown**




**Artemisinin**  
**anti-malarial drug**



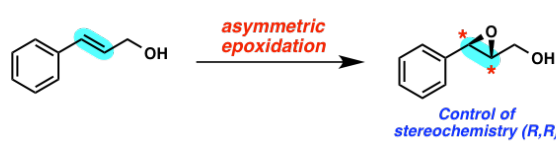
**Nobel Prize:**  
"for their development of the use of boron-containing compounds into important reagents in organic synthesis."

**BACON Fact:**  
Brown ran a humor column in high school and won a national prize.




**2001 Nobel Prize in Chemistry**  
April 28, 1941 – Present

**K. Barry Sharpless**




**reboxetine**  
**drug for the treatment of depression**



**Nobel Prize:**  
"for his work on chiral catalysed oxidation reactions."

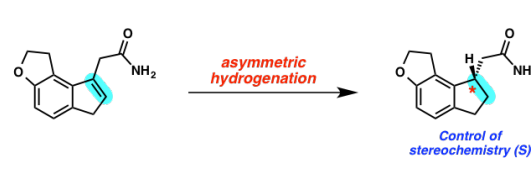
**BACON Fact:**  
He was blinded in one eye during a lab accident in 1970

Note: we will look at this reaction in Chem 12B.





**2001 Nobel Prize in Chemistry**  
June 1, 1917 – June 13, 2012

**William S. Knowles**



**Ramelteon**  
**sleeping pills**





**2001 Nobel Prize in Chemistry**  
Sept. 3, 1938 – Present

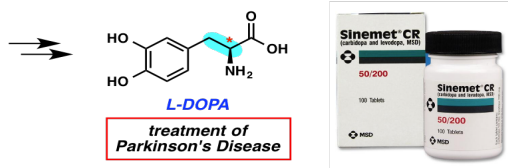
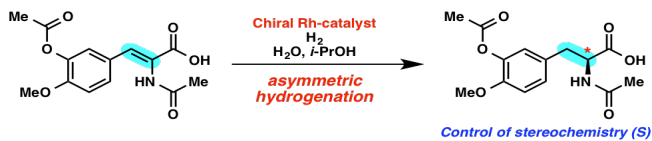
**Ryoji Noyori**

**Nobel Prize:**  
"for their work on chiral catalysed reduction reactions."

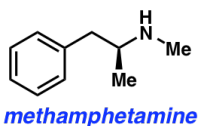
### 13. Anti-depressants

Synthesis of L-dopa (a precursor to adrenaline):

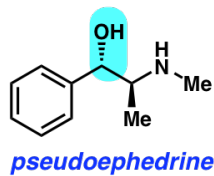
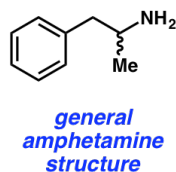
Industrial synthesis of L-DOPA using Asymmetric Hydrogenation



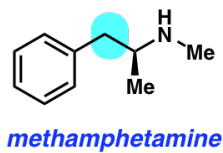
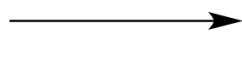
14. Sudafed contains pseudoephedrine



Illegal and Dangerous Drug



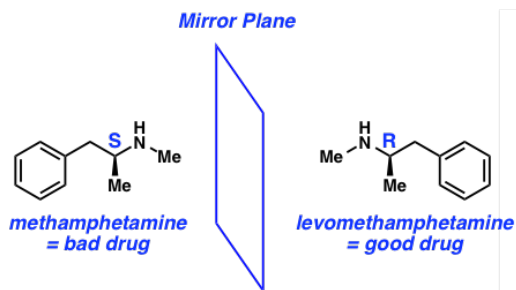
Nasal Decongestant



Illegal and Dangerous Drug

Methamphetamine enantiomer is levomethamphetamine, which is a vasoconstrictor and helps alleviate nasal congestion. Levomethamphetamine is found in vapor inhalers.





Note: a group of 2 can do these reactions. 1<sup>st</sup> reaction is amphetamine to methamphetamine. 2<sup>nd</sup> reaction is pseudoephedrine to methamphetamine. The other possible product is \_\_\_\_\_. The major product is \_\_\_\_\_ because \_\_\_\_\_.

## INDUSTRIAL REACTIONS

Ethylene and propylene are 2 of the Top 10 chemicals produced in the US and are used to make many compounds. Ethylene and propylene are used to make polyethylene and polypropylene, which are 2 very common plastics. Plastics are a type of polymer.

15. Cationic polymerization: styrene  $\rightarrow$  polystyrene (styrofoam). See Chem 12A Objective 12 Lecture Slide 33 and Klein, "Organic Chemistry" textbook, p. 405.

16. Radical polymerization:

Examples:

a. ethylene  $\rightarrow$  polyethylene

b. propylene  $\rightarrow$  polypropylene

c. vinyl chloride  $\rightarrow$  polyvinylchloride (PVC plastic)

See Chem 12A Objective 14 Lecture Slides 30-38.

Note: a group of 2, 3, or 4 can do 2, 3, or 4 of the reactions in 15 and 16.

17. addition reaction: acetylene  $\rightarrow$  vinyl chloride

Note: a group of 2 can do this reaction and the vinyl chloride to PVC reaction.

18. ethylene  $\rightarrow$  tetrachloroethylene (perchloroethylene, PERC) – used in dry cleaning fabrics and degrease metal parts.

Note: there are several ways to make PERC from ethylene. A group of 2 or 3 or 4 can do some or each step of this synthesis.

19. Other alkyl halides are used as solvent or dry cleaning fluids. You and your group can identify a solvent or dry cleaning fluid and explain the synthesis of this compound from ethylene or propylene.