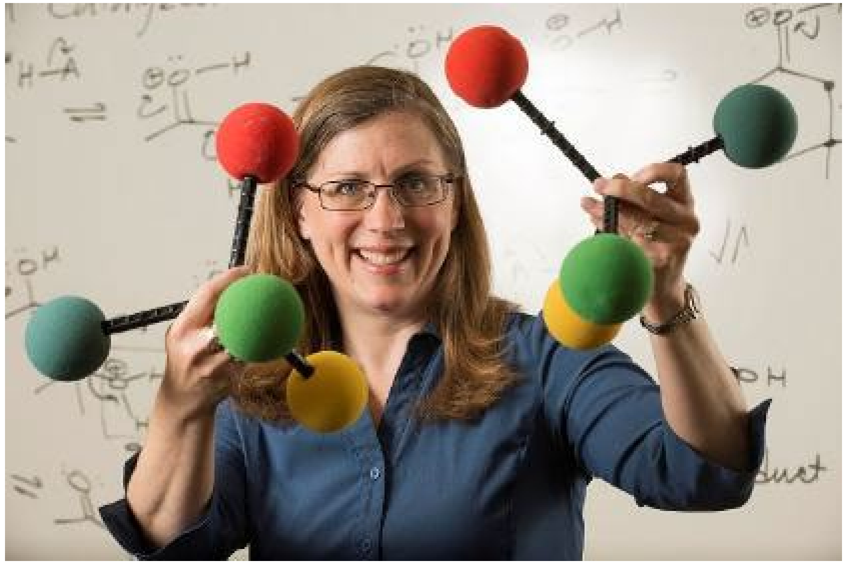
Designing a Course to Cultivate

Capable Chemists

Productive Students

Engaged Citizens



Laurie S. Starkey

Cal Poly Pomona

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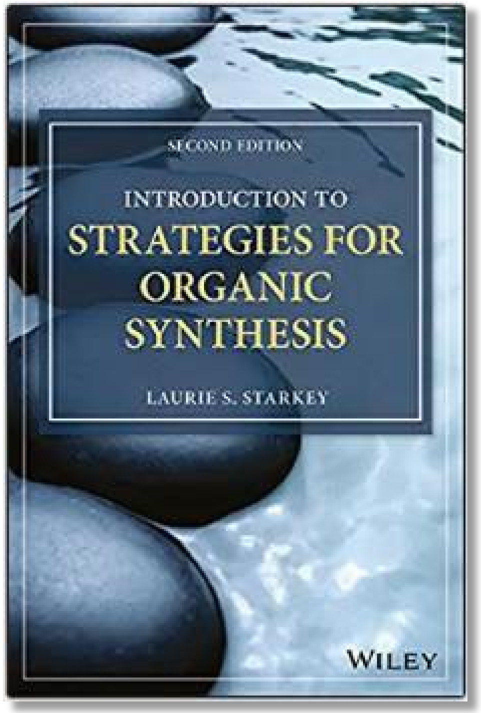
BCCE 2026

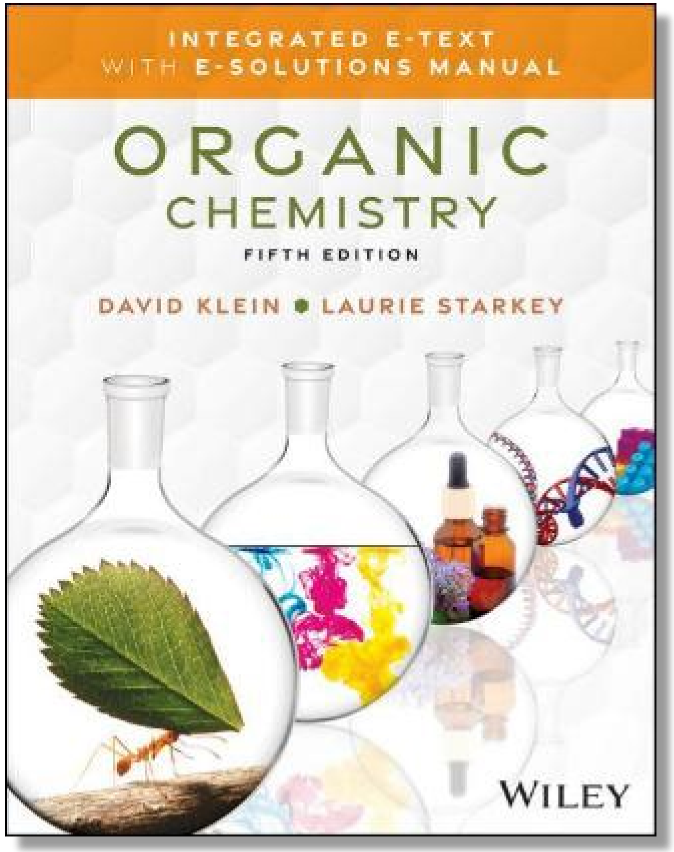
About me…

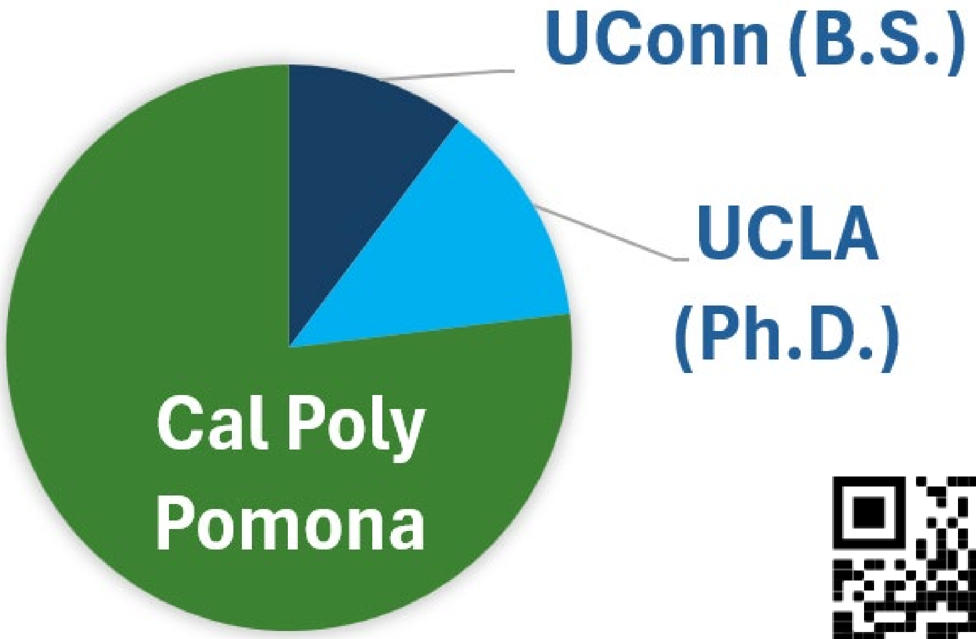
Cal Poly Pomona

30 miles east of Los Angeles

Est. 1996





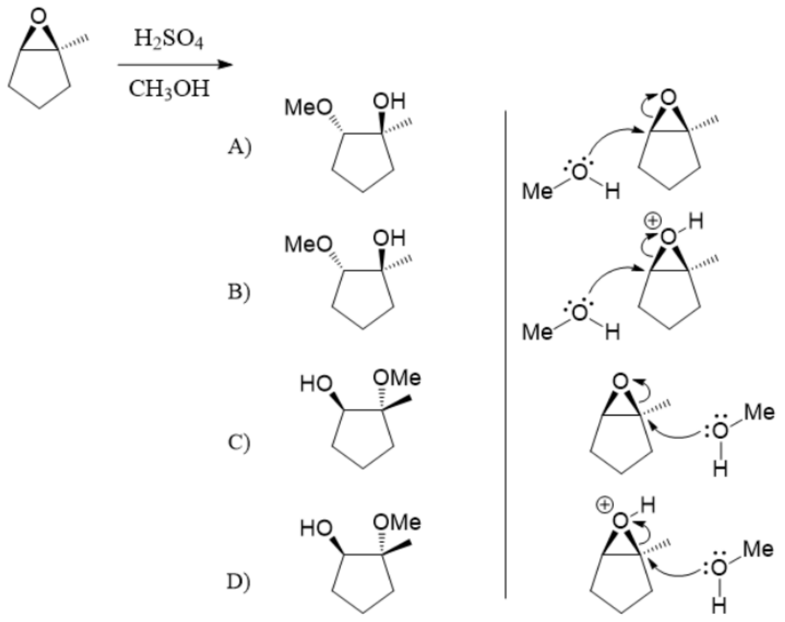


chemistryconnected.com

Flipped Classroom for Active Learning

- Daily worksheets: Learn by *Doing*
- Model problem solving
- Demonstrate tips/tricks

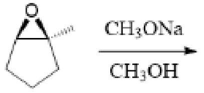
Predict the major product, and select the correct mechanism step.



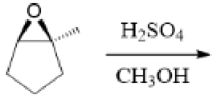
CHM 3150 Organic Chemistry II
Dr. Laurie S. Starkey, Cal Poly Pomona
Chapter 13 Ethers & Epoxides Part 2 – Practice Problems

For clicker question voting, go to:
https://pollev.com/lauriestarke263

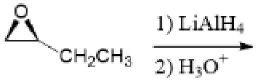
1 Predict the major product, and draw the mechanism.



2 Predict the major product, and draw the mechanism.



3 Predict the major product, and describe the mechanism.



A) Protonate, attack, deprotonate
B) Protonate, attack
C) Deprotonate, attack
D) Deprotonate, attack, protonate
E) Attack, protonate

Which is the stronger acid? Explain briefly.

H_2O NH_3

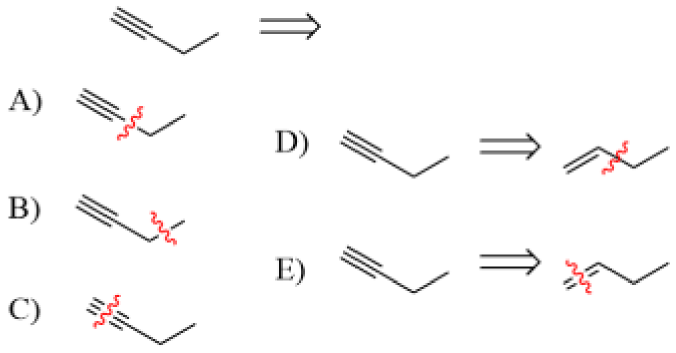
A) H_2O is the stronger acid because HO^- is **more** stable than H_2N^-.

B) H_2O is the stronger acid because HO^- is **less** stable than H_2N^-.

C) NH_3 is the stronger acid because H_2N^- is **more** stable than HO^-.

D) NH_3 is the stronger acid because H_2N^- is **less** stable than HO^-.

Which represents a logical disconnection in the retrosynthesis of the given target molecule?



Flipped Classroom & “Clicker” Questions

- Engaging – when you click, you are invested
- Encourages student participation – discuss with a neighbor (think/pair/share)
- Discuss common mistakes
- Can be used creatively (e.g., study tips)

Capable Chemists

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To prepare for an organic chemistry exam, what is the best use of my time?

A) Watch YouTube videos. ?!!

B) Work on textbook problems. #1

C) Rewrite my notes. passive

D) Rewatch the Educator lectures. passive

E) Attend office hours. Got Questions?

lecture

worksheet

textbook problems

"Clicker" Questions & Worksheets LOCAL

L O C A L

Library for Organic Chemistry Active Learning

Created by Laurie Starkey, Professor of Organic Chemistry at Cal Poly Pomona
To contribute materials, please contact Laurie (and thank you!) lsstarkey@cpp.edu

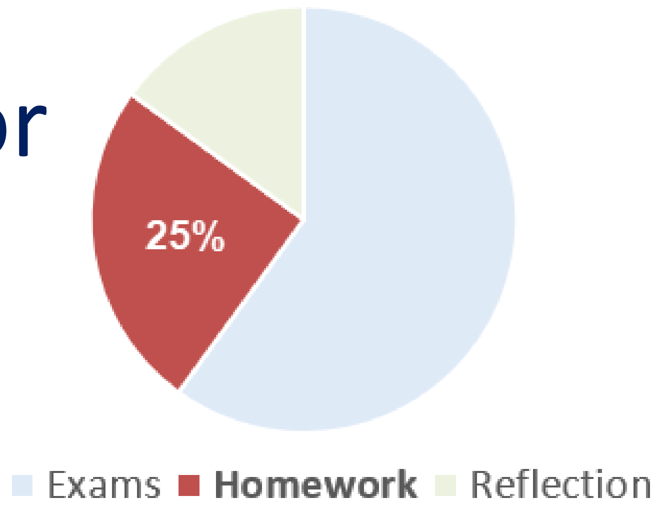
Active-Learning Resources can also be found here: *organicERs.org* | *MERLOT.org*
see also: **student motivation resources**

Clicker Questions:

Bonding/Structure, Acid-Base, Nomenclature	Stereochem, Radicals, Study of Reactions	Substitution & Elimination Alkene/Alkyne Reactions	Alcohols, Ethers & Epoxides
Lewis Structures & Line Drawings Resonance & Hybridization/3-D Acid-Base MO Theory Physical Properties Nomenclature Sites of Unsaturation (DU) Conformations of Alkanes & Cyclohexanes	Chirality & Optical Activity R/S, E/Z Nomenclature Stereochemical Relationships Radical Reactions Thermodynamics, Kinetics & Reaction Coordinate Diagrams	Substitution Reactions (Sn1/Sn2) Elimination Reactions (E1/E2) Substitution vs. Elimination Dehydration of Alcohols Alkene Additions and Oxidation Alkyne Reactions Synthesis Strategies (Klein Ch. 11)	Alcohol Reactions Grignard & Hydride Reagents Epoxide & Ether Reactions Alkoxides & Thiols Syntheses Involving Alcohols
Carbonyl Chemistry	**Alpha-Carbon Chemistry**	**Conj. Systems, Aromaticity**	**Additional Topics**
Aldehydes & Ketones Acetals & Protective Groups	Enols & Enolates	Conjugated Dienes (Diels-Alder, 1,2/1,4-Addition)	Amine Reactions & Synthesis

Textbook Problems = Formative Assessment

- If you value it, assign points to it… and then ***students value it!***
- Encourages self-assessment and use of Solutions Manual
- 25% of course grade based on In-Chapter (SkillBuilders) and/or End-of-Chapter Problems



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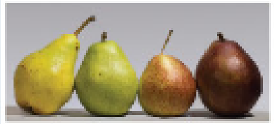
Course Credit for Practice Problems

Cultivating Capable Chemists

Organic Chemistry II CHM 3150, Dr. Laurie S. Starkey, Cal Poly Pomona
Ch. 20 (Klein-Starkey): Carb. Acids & Derivatives, Textbook Problems Cover Sheet

Name: ______________________ **Signature:**______________________

By signing, you are confirming that the work you are submitting is your own.



What these pears all have in common is the butyl acetate that contributes to their fragrance and flavor.

To earn 10 points course credit, you must write and sign your name above, check one of the boxes below, and submit this page to Gradescope. If you worked problems by hand on paper (or tablet), complete this cover page and include it as the first page of the pdf you submit. Use Genius Scan (or equivalent app) to convert your handwritten homework to a clean, readable pdf: ***please crop your pages and apply a Black & White filter.***

Handwritten and/or WileyPLUS problems? Please mark the appropriate box below.

☐ hand-written only ☐ hand-written problems & WileyPLUS ☐ WileyPLUS only

For hand-written work, students need to do at least 40 problems for full credit. You are expected to use the SSM to self-grade your hand-written work, and it should not be error-free or without corrections! *Students who simply copy answers from the Solutions Manual and submit them as their own work will not earn credit on this assignment.* In WileyPLUS, there are over 300 points that can be earned (~2 points per problem). **A WileyPLUS score of 80 or higher will earn full homework credit.** Partial homework credit will be given for scores below 80.

Suggested Ch. 20 problems **Mechanisms and **Synthesis (good to work on by hand)*

In-Chapter Problems (includes **SkillBuilders 20.1–20.3**)

20.1a–f	20.10adf	20.18a–c*	20.26a–c
20.2a–f	20.11 a–l (skip g)	20.19a–c	20.27b**
20.3a–d	20.12 c–h	20.20a–d	20.28*
20.4	20.13a–c*	20.21**	
20.5	20.14*	20.22**	
20.6	20.15a–f	20.23*	
20.7*	20.16ab*	20.24a–d	
20.9ab	20.17a–d	20.25**	

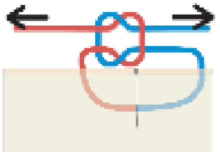
Ants produce the simplest carboxylic acid, formic acid.

End-of-Chapter (EOC) Problems

20.35b	20.42ab**	20.58
20.36	20.44 a–h (skip g)	20.59a–e
20.37c–g	20.45a–d	20.60
20.38a–c	20.46 a–h (skip c & e)	20.61a–e*
	20.47	20.62ab
	20.48ab**	20.63
	20.49A–D	20.65
	20.50a–f**	20.70
	20.52ac**	20.71
	20.54**	20.72
	20.55	20.73
	20.56*	20.74

When a fir tree is damaged by an insect, the tree defends itself by producing a compound that mimics an insect hormone, thus disrupting the insect's ability to undergo metamorphosis (i.e., proceed through its developmental stages).

Problem 20.31 (SB 20.2)



If you want to be a surgeon, you will have to learn various suturing techniques, such as how to tie this square knot.

Problem 20.65

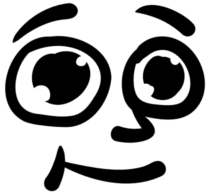
Provide a Supportive Learning Environment

How my students feel about Organic Chemistry (and how they feel about me) matters! Why?

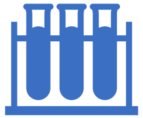
- Emotions drive our attention, memory, learning
- A student who is unmotivated or has a negative view is likely to give up *when* they hit a roadblock

G.P.S. of Motivation (Motivate Lab, BCCE 2022)

✓ **G**rowth Mindset
✓ **P**urpose &a Relevance
✓ **S**ense of Belonging



See also: Affective Domain, Emotional Intelligence, EQ



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Study Habit #1 – Make Flashcards

- Created from YOUR notes/textbook
- No limit to topics (nomenclature…)
- Variety of skills (missing product/reagents/substrate)
- No tech needed, so offers ultimate mobility
- Can remove cards as proficiency improves
- Cards can be shuffled (final exam prep.)
- Future use: stack can grow in Organic II, good review for MCAT, DAT, PCAT, grad school exams…

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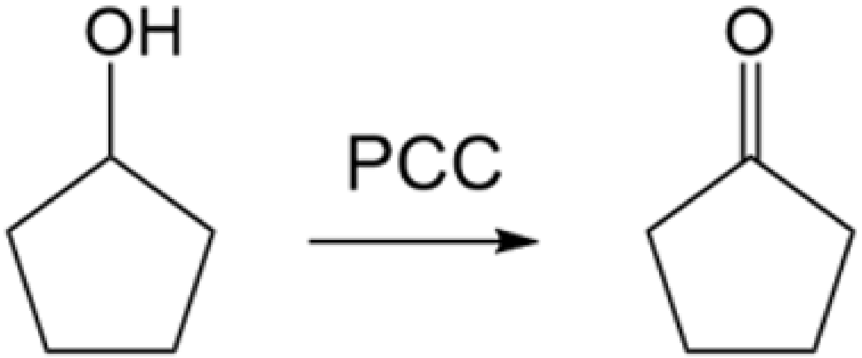
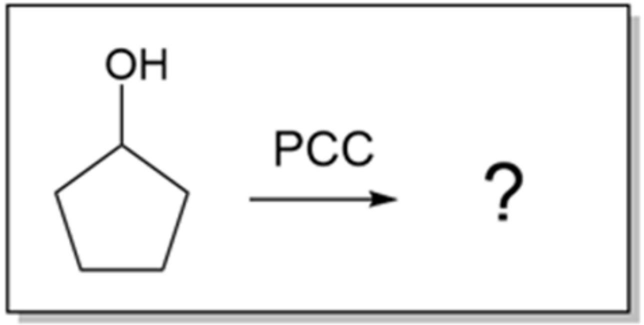
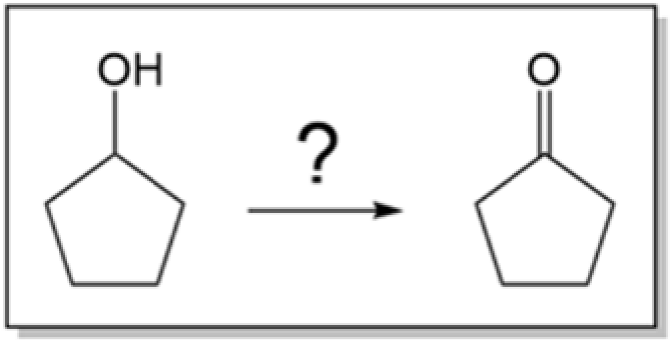
Every new reaction creates THREE flashcards

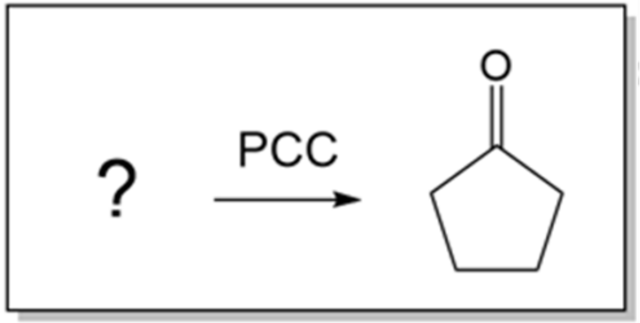




skill = **predict product**

skill = **recall reagents**





skill = **retrosynthesis**

Skill being developed: ~~intuition~~ rapid pattern recognition

Study Habit #2 – Join a Study Group

Organic Learning Community (OLC)

- Self-formed groups of 3-5 students
- Work on o-chem with your group 1 hr/week
- 1 point credit for weekly report w/selfie pic (7 points max. out of 500 total points)
- Opting out won't hurt grade (not announced)
- Positive feedback blew me away! Testimonials

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Study Habit #3 – Metacognitive Reflection

Exam Wrapper Assignments

- Survey given after each midterm exam (x3)
- Students reflect on…
  - ✓ how they prepared
  - ✓ what mistakes they made
  - ✓ how they will prepare differently next time
- 4 points for survey + 4 points for corrections (16 points max. out of 500 total points)
- Students ask LOTS of questions now! (regrade request feature in Gradescope)

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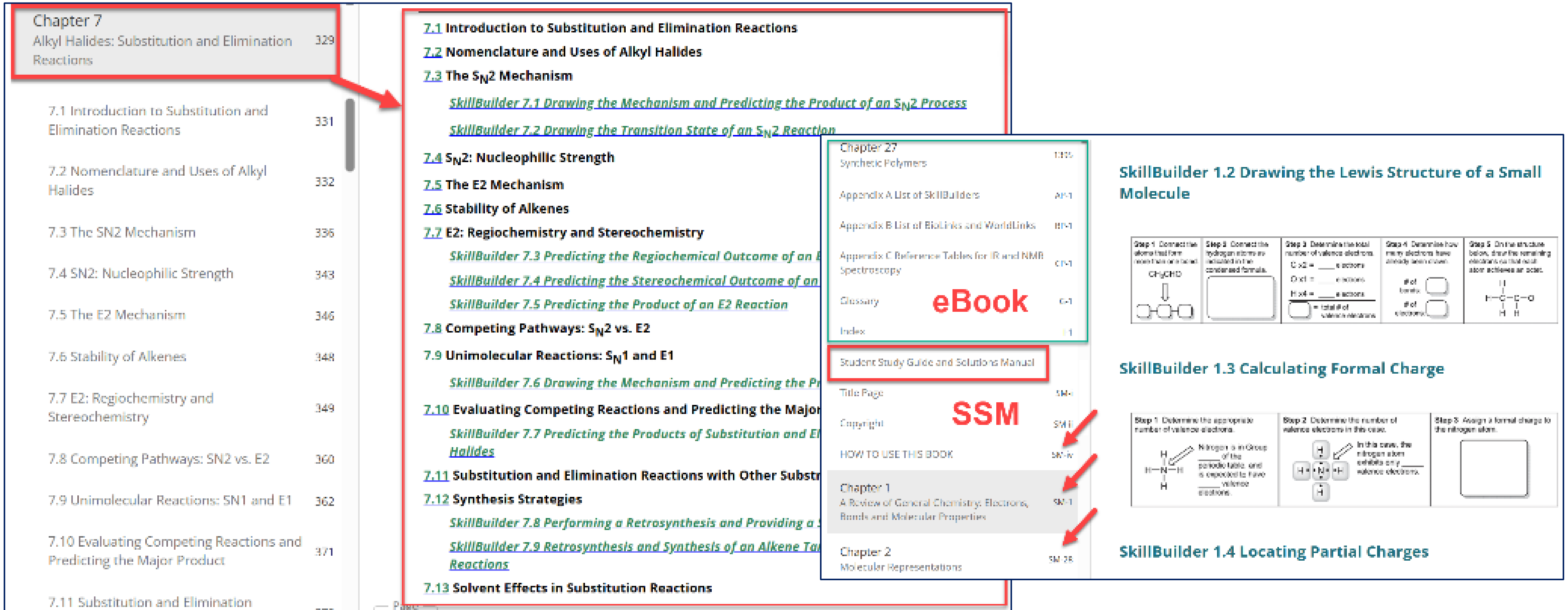
Study Habit #4 – ENGAGE with Textbook

Me, "Textbook problems, textbook problems…"

Student, "What do you mean?"   Me: 😱

Better to be more explicit: "Try SkillBuilders 7.8 & 7.9"

Also, show the class where to find eBook, TOC, SSM…



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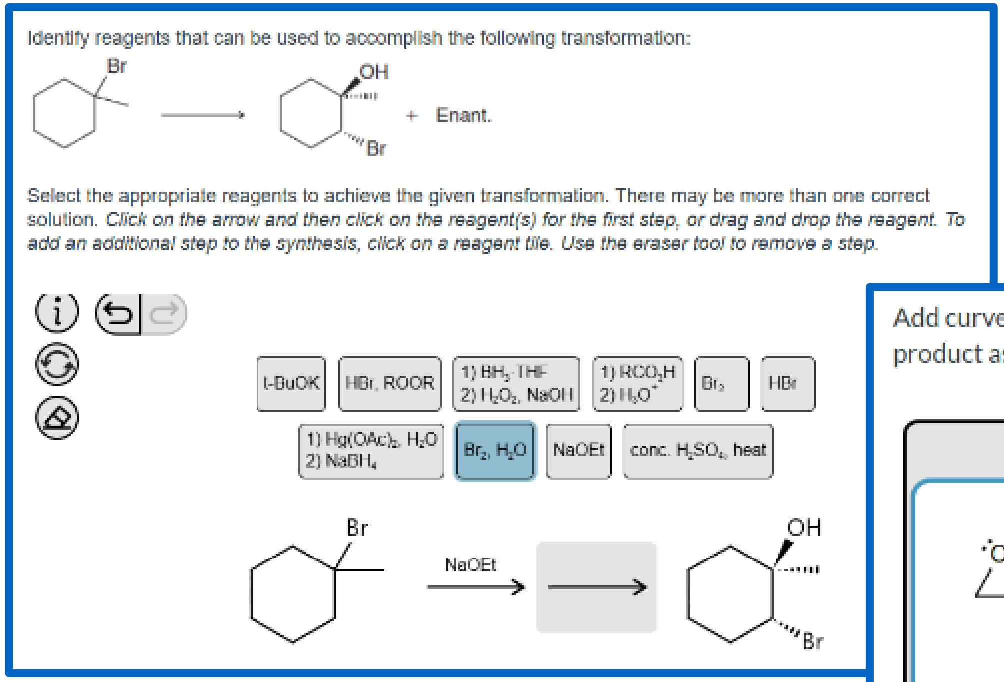
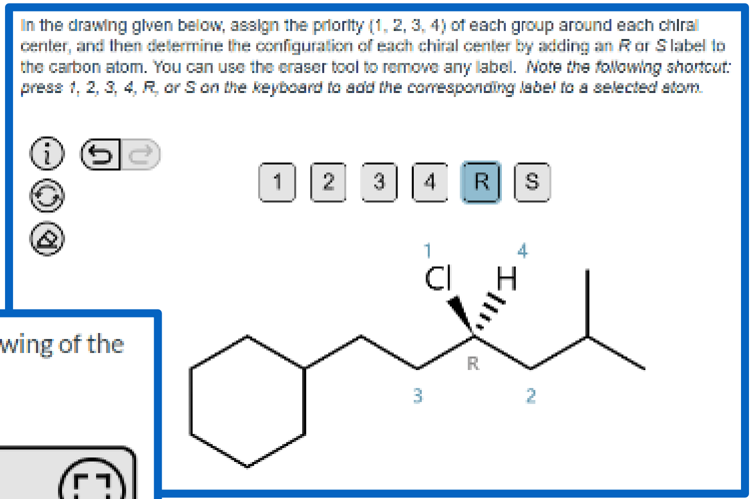
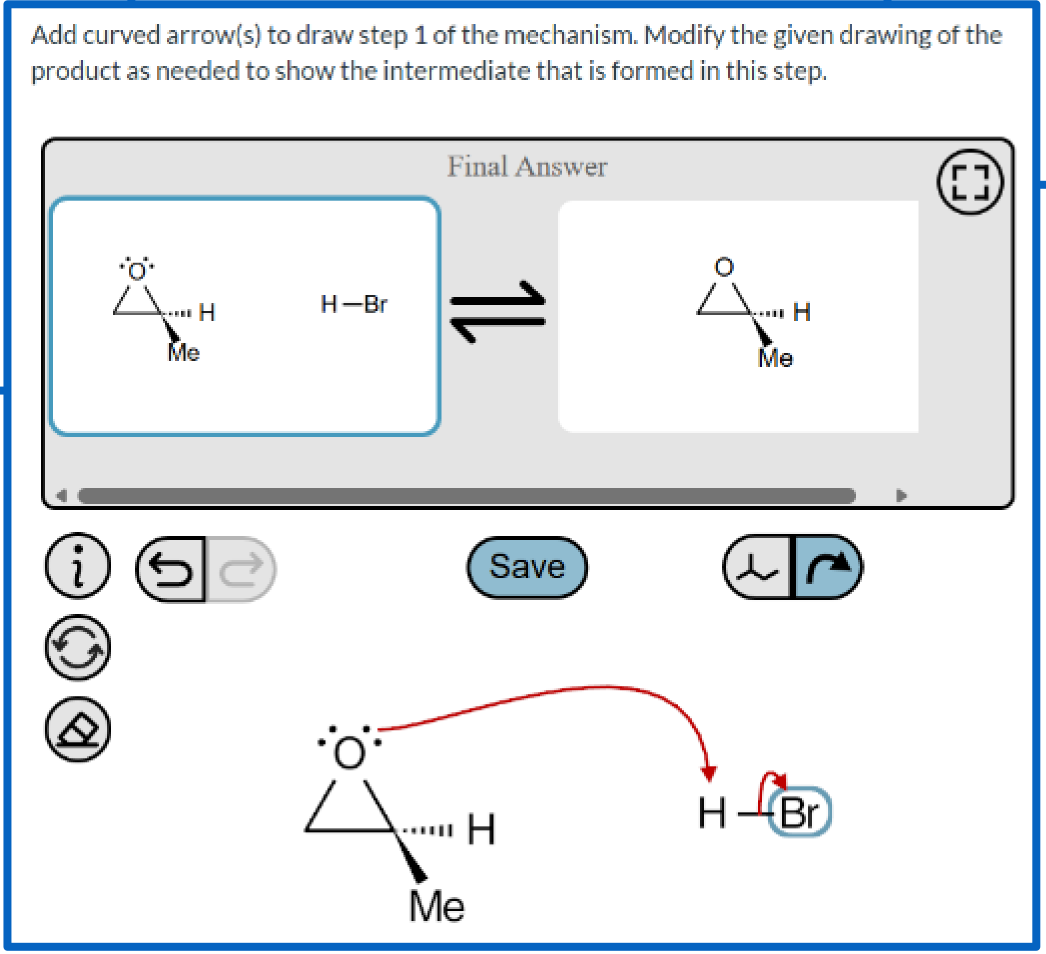
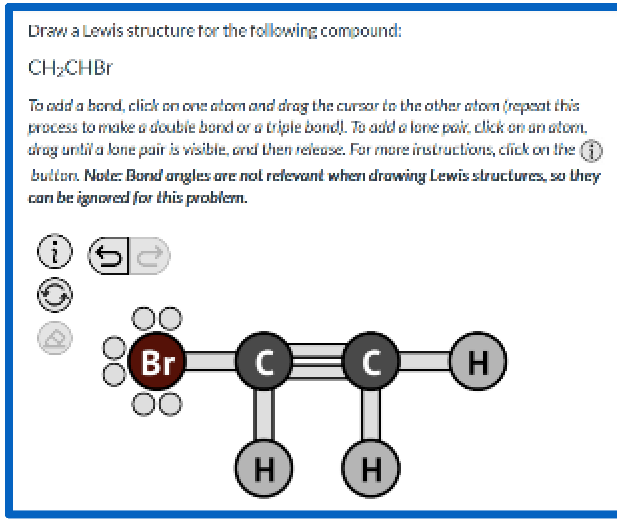
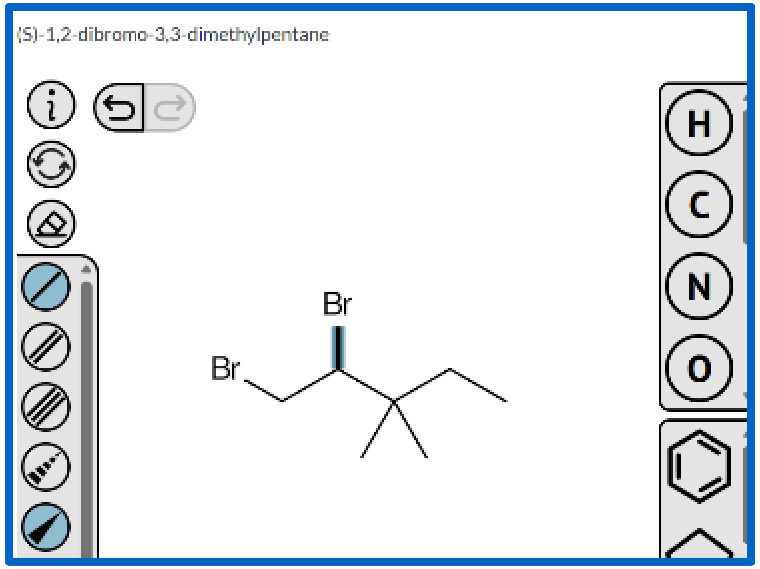
Demonstrate Online Homework Drawing Tools



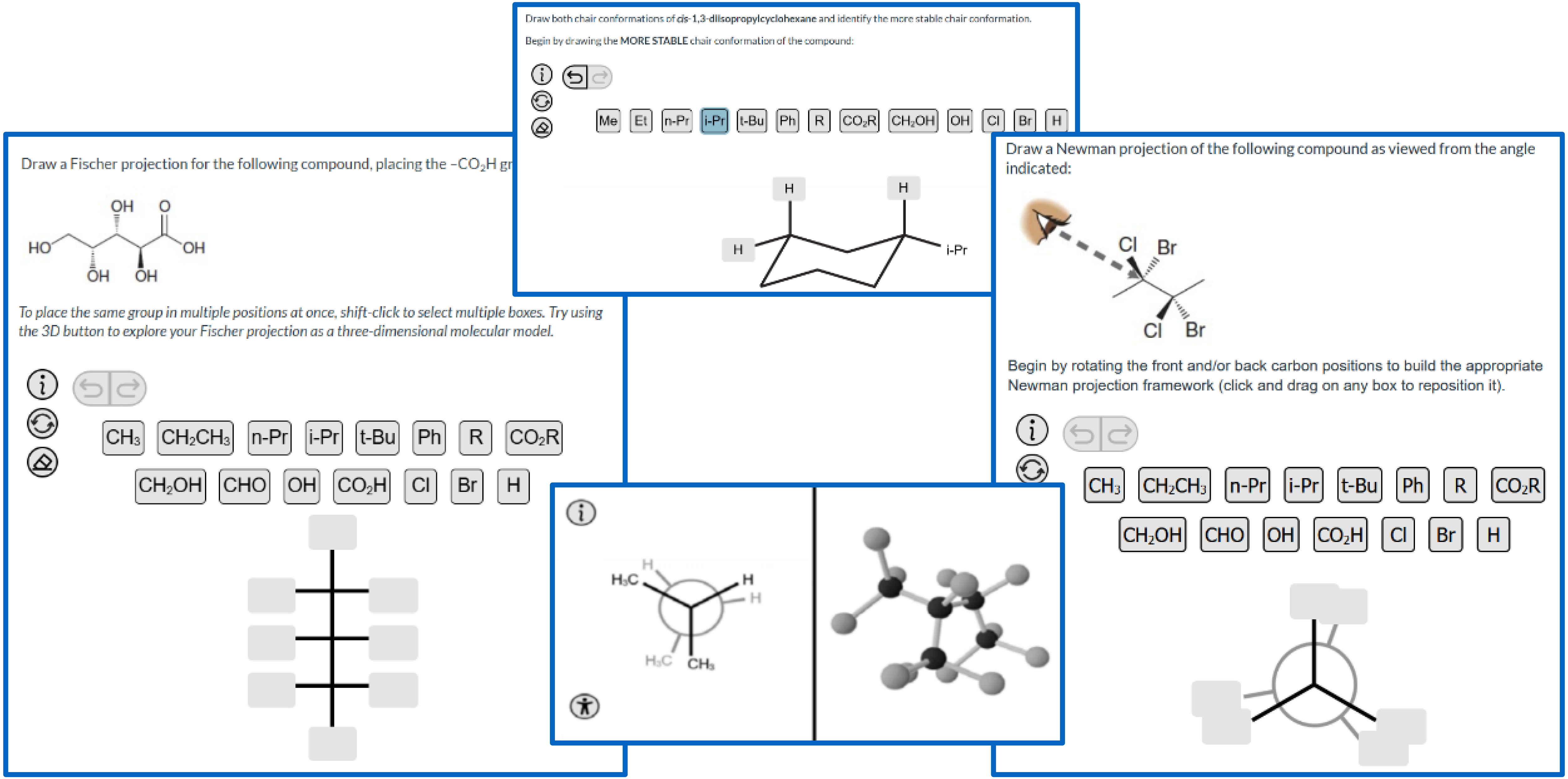








Demonstrate Online Homework Drawing Tools



Beyond the *Chemistry Student*…

- Future Doctor? Pharmacist? Teacher?
- Future Chemist who doesn't yet know it?!
- Future Brewer? Activist? Senator?
- Future parents? School Board members?
- Consumers, voters making informed decisions.

College experience can be transformative. With faculty mentorship, it can lead to self-discovery.

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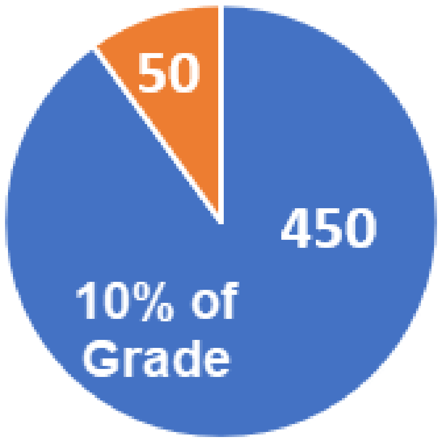
Beyond the *Chemistry Student*…

Education should influence people's lives beyond the boundaries of the classroom.

Engaged Citizens

Weekly "Friday Five" Reflection



1) Describe how you spent your time working on Organic Chemistry this past week.

2) Describe your plan for working on Organic Chemistry this coming week.

3) **The 3rd writing prompt can explore...**

Engaged Citizens

Careers

Medicine & Health

Earth Day

Natural Products Synthesis

History

NCW & Volunteering

Cannabis Chemistry

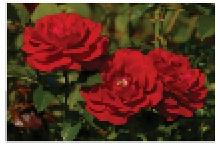
Weekly “Friday Five” Reflection

Engaged Citizens

Throughout history, humans have devised many practical purposes for fragrances: perfumes conceal body odors, essential oils provide relaxing aromatherapy, and pleasant-smelling soaps and shampoos are appealing to use. Plague doctors in the 1600s theorized that miasmas, or the smell of decomposition, was the cause of the spread of the Black Death. To protect themselves while treating the sick, they would place aromatic herbs and flowers in the beaks of their masks to combat the odors of disease and decay.

Fragrant materials filled the beaks of masks worn by plague doctors.

WorldLinks | Fragrances and Perfumes



Rose fragrance is a complex mixture of organic compounds, including alcohols, alkenes, and

It's certainly good advice to "stop and smell the roses" as you go through life. Such a pause benefits your mental health by providing an opportunity for reflection. Smelling roses might also increase our appreciation for organic chemistry, because organic molecules are responsible for most of the odors we encounter each day! Fragrances can have a tremendous impact on our minds and bodies. They can increase our appetite, or they can turn our stomach and make us sick. A certain odor might evoke images of a holiday or a favorite meal, or cause you to recall a childhood memory. In each case, a molecule or, more likely, a complex mixture of molecules is interacting with odor receptors in your nose and sending powerful signals to your brain. In response, an emotional reaction might be triggered, or perhaps your mouth will start watering!

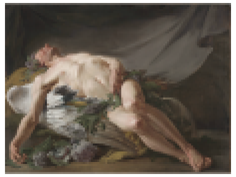
but also materials obtained the anal glands of civet cats.

synthetic fragrances were produced. With the tools of organic synthesis at their disposal, chemists can produce affordable aromas, design novel fragrances, and develop alternatives to products harvested from animal sources. Fragrances are not only used to make perfumes and colognes (and air fresheners and scented candles...), but they are also added to many personal care and household products.

Perfumes use natural and/or synthetic fragrances.

BioLinks | The Opioids: Miraculous and Murderous

For thousands of years, humans have used opium for its pain-relieving, sedative and euphoric effects. The natural substance is obtained from the unripe seed pods of the poppy plant, and it is traditionally smoked by users. Dating back to at least 3400 BC in Mesopotamia, opium was widely traded across the world. Its use is documented throughout history, ranging from religious rituals to medieval medical books to opium dens. Poppies can be found adorning Egyptian, Greek and Roman gods in ancient images and statues. The biologically active component of opium is the compound morphine, named after Morpheus, the Greek god of sleep.

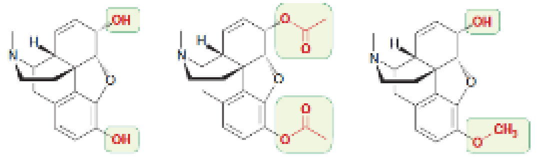


Morpheus, the god of sleep and the namesake of morphine, is often depicted holding poppies.

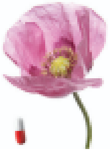
Morphine and similar molecules (such as heroin, codeine, and fentanyl), are members of a drug family called opioids. Molecules in the opioid family bind to opioid receptors in the nervous system and block the transmission of pain signals to the brain. As a result, they are potent analgesics (pain relievers). In addition, opioids are known to act as depressants (causing sedation, constipation, and slower respiratory function), and at high doses they can produce a state of euphoria. Morphine is addictive, so it is primarily used for the short-term treatment of acute pain and for terminally ill patients suffering from extreme pain. Morphine was first isolated from opium in 1803, and by the mid-1800s, it was used heavily to control pain during and after surgical procedures. By the end of the 1800s, the addictive properties of morphine became apparent, which fueled the search for nonaddictive analgesics.

As mentioned in the chapter opener, there are many techniques that scientists employ in the design of new drugs. One such technique is called lead modification, which involves modifying the structure of a compound known to exhibit desirable medicinal properties. The known compound "leads" the way to the development of other similar compounds and is therefore called the lead compound. A story that begins with morphine provides a good example of this process.

In 1925, the structure of morphine was correctly determined. Functioning as a lead compound, the structure of morphine was modified to produce other compounds with analgesic properties. Early modifications focused on replacing the hydroxyl (OH) groups with other functional groups. Examples include heroin and codeine:



Morphine Heroin Codeine



WorldLinks | Organic Chemistry Illuminates Humankind

In the modern world, we can summon light by simply flicking a switch or using an app on our phones. But what did humans use for light before the relatively recent inventions (developed within the past 150 years) of electricity and lightbulbs? Prior to the late 1800s, the only available light on earth was light from the sun and light produced by fire. For over 200,000 years, humans have been generating light by burning organic material. Nearly 40,000 years ago, toward the end of the lamps to burn animal fats. The lar the inside of caves where we now

Carbide lamps were also used throughout the mining industry in the early 1900s. Compared to candles and oil-based lamps, the light from the carbide lamp was brighter, and the acetylene fuel was better because it consumed less oxygen and produced no carbon monoxide. Small lamps could be affixed to the front of a cap, and larger lamps were carried by hand. An open flame is dangerous in coal mines where pockets of flammable methane

$$\underset{\text{calcium carbide}}{Ca^{2+}\ {}^{-}C{\equiv}C^{-}} + \underset{\text{water}}{2\ H_2O} \longrightarrow \underset{\text{acetylene (g)}}{HC{\equiv}CH} + Ca(OH)_2$$

A carbide lamp has two chambers that are connected by a threaded valve. Calcium carbide is added to the lower chamber, and water is added to the upper chamber. When the valve is partially opened, water from the upper chamber drips onto the calcium carbide and acetylene is produced. The generated acetylene gas is passed through a metal tube, and the stream of gas is ignited as it exits the lamp (using a match or a spark from a built-in flint striker). The size of the flame—and the corresponding brightness of the lamp—can be modified by controlling the rate of water entering the lower chamber. The portable nature of the lamp made it suitable for use as a headlight for bicycles around the turn of the 20th century and for early automobiles.

The **Safety Data Sheet (SDS)** for calcium carbide has the following label elements in accordance with the Globally Harmonized System (GHS) of Classification and Labelling of Chemicals.

Signal word: Danger

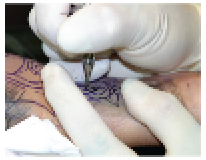
Pictograms:

Hazard Statements:

- In contact with water releases flammable gases, which may ignite spontaneously
- Causes skin irritation
- Causes serious eye damage
- May cause respiratory irritation

WorldLinks | The Chemistry of Temporary and Permanent Tattoos

Tattoos are found in many cultures worldwide. Many of these tattoos have cultural, social, or religious significance. They may be given as a rite of passage into adulthood or as part of a religious ritual, or they may indicate social status or warrior class. Tattoos consist of pigments which are applied on or below the top layer of skin. Pigments that are absorbed in the top layer of the skin (the *epidermis*) are not permanent and gradually fade as the outer skin cells slough off. Pigments that are injected deeper into the skin (the *dermis*) become permanently embedded there.



The tattoo design is first transferred to the skin, and then it is traced over with needles covered in ink.

Nanaia Mahuta served as New Zealand's Minister of Foreign Affairs from

The earliest known tattoos date back to ~3250 BC, on a glacier mummy (called Ötzi) that was found in the Italian Alps. The mummified body of Ötzi revealed 61 tattoos. The lines that were tattooed on his lower legs, lower back, wrist, and torso may have been applied for therapeutic purposes. Tattoos have been found on female mummies in Egypt dating to ~1300 BC. These ancient tattoos were made

They can even be used as permanent make-up on the eyes and lips. Tattooing also serves an important function when it used to restore features that were lost to surgery, injury or illness. After a reconstructive breast surgery, for example, the mental well-being of the patient can be improved when a tattoo artist adds a realistic-looking areola.

Likewise, for someone missing a belly button or a fingernail, getting a tattoo can restore a sense of wholeness.

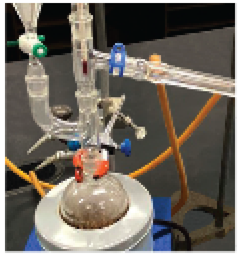
Let's take a look at some of the organic compounds used in tattoo art. Henna dye imparts a reddish-brown color when applied to hair or skin, and it has been used for thousands of years. The leaves and stems of the henna plant contain lawsone, an organic compound that undergoes a chemical reaction with keratin, a protein found in hair and skin. After a design is drawn on the skin using henna, the henna reacts with the skin's keratin. This reaction causes the skin to be stained, and the applied design becomes a temporary tattoo that lasts for up to 6 weeks. To make a black tattoo, other compounds are added to the henna, such

An Indian wedding tradition is to apply intricate Mehndi (henna) designs to the bride's hands, as a way to bestow good luck to the marriage.

Weekly "Friday Five" Reflection

Engaged Citizens

11.7 Natural Product Synthesis

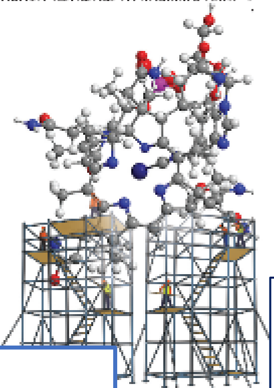


In a steam distillation, the essential oil of a plant is isolated as it co-distills with water.

"There is no denying (nor should there be any need to deny!) that the sheer sense of challenge posed by a complex molecular target serves to stimulate the creative impulses of the synthetic chemist." Samuel J. Danishefsky (Columbia University)

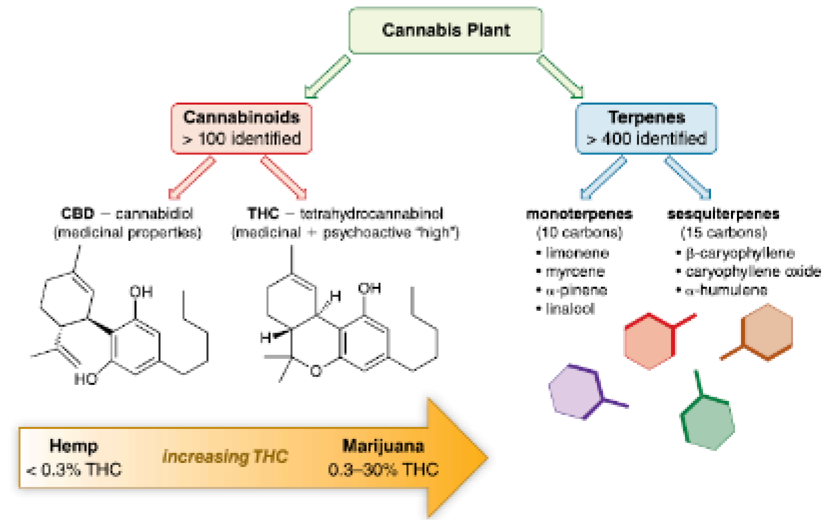
Many significant synthetic achievements have been in the area of *natural product synthesis*. Compounds made by nature are often attractive targets for synthesis because they are likely to be biologically active. For thousands of years, humans have used herbal remedies to alleviate pain, treat wounds and cure various ailments. Therefore, it makes in search of compounds that might have antibiotic pro *Natural product chemists* do exactly that—they gather s etc.) and isolate the organic components that are presen volatile, fragrant components such as terpenes, might be extraction techniques can be used to isolate other comp or basicity. The search for interesting organic compound they can also be found in sea creatures and microorganis organic compounds are isolated, their structures are det learn about in Chapters 14 and 15: IR and NMR spec trometry. In some cases, the three-dimensional structure how the crystal interacts with X-rays; this powerful tec Any novel compounds that are identified can then be scr

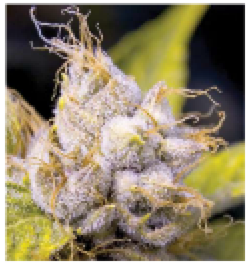
Recall from the WorldLink lesson on terpenes in Chap



BioLinks Terpenes and the Chemistry of Cannabis

Have you ever felt energized and clear-headed after a walk through a pine forest? Or perhaps you have enjoyed a good night's sleep after having a relaxing bath with lavender bath salts? If so, you have had some first-hand experience interacting with terpenes. Earlier in the chapter we saw a few examples of terpenes that are found in essential oils, and in this BioLink we will learn

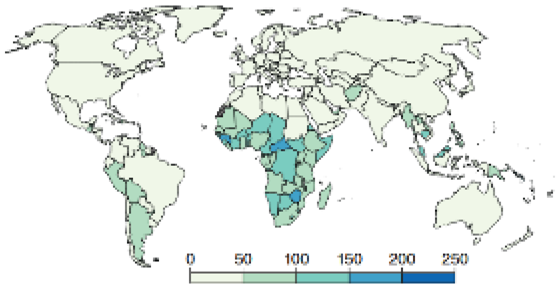




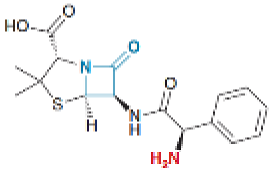
Cannabis flowers are covered with tiny hairs (called trichomes) that secrete a sticky resin, rich in organic compounds.

WorldLinks Saving Lives with Azo Dyes

Pneumonia is one of the most common causes of death worldwide, and it kills more children than any other infectious disease. Every year, pneumonia takes the lives of over 650,000 children under the age of five. Antibiotics are a relatively cheap and effective treatment because most cases of pneumonia are caused by bacteria. In the United States, most children have access to healthcare and effective β-lactam antibiotics such as amoxicillin and ampicillin, so pneumonia is not a leading cause of death. Children living in impoverished parts of the world, however, are much more likely to die from pneumonia.



The estimated annual death rate from pneumonia and other lower respiratory tract infections per 100,000 people.



ampicillin
1° amine
β-lactam

The reason low-income countries have higher death rates is i inadequate healthcare infrastructure hampers the diagnosis and treatment of pneum ble to afford treatment—but the reality behind the inequality is far more complex. Other c vaccines, undernutrition, a lower prevalence of breastfeeding, environmental pollution, secondhand smoke, and overcrowded living spaces.

Another challenge in treating deadly diseases in developing countries is the presence of substandard or falsified drugs in the supply chain. In 2017, the World Health Organization reviewed over 100 papers about the quality of commercially available

Weekly "Friday Five" Reflection

Engaged Citizens

CCEW 2026 Trees and Forests: Into the Woods with Chemistry!

Find educational resources for this year's Chemists Celebrate Earth Week theme and other materials for your event, including outreach activities, activities, articles, and videos.

CHEMISTS CELEBRATE EARTH WEEK

Elementary (K-5) Resources

- Sunshine for Life

  Students will use role-play and

Middle School (6-8) Resources

- Investigating Photosynthesis

  ts will analyze evidence to understand the process of ynthesis.

High School (9-12) Resources

- Sustainable Energy Evaluation

  Students will compare the pros and cons of a sustainable resource, research the cost and benefits of the resource, and

WorldLinks Organic Chemistry as a Second Language

At this point in the course, you may be starting to appreciate the title of the popular workbook, "Organic Chemistry as a Second Language." The volume of vocabulary in Chapter 5 can be overwhelming—chiral, achiral, enantiomer, diastereomer, meso, optically active, levorotatory, dextrorotatory, *R/S*, *cis/trans*—and there is still more to come! It is very much like a foreign language. At the same time, it is critical that you learn the language because that is how we communicate. We will be using this vocabulary again and again in future chapters and throughout the entire year of the orga

become fluent in a foreign language,

ply reading the written words and le

We must *hear* the language and spea

our new vocabulary! To become flue

we must do the same. Try making fl

word you encounter, and say the w

out loud as you study. Working with

great way to get practice talking out

provide an opportunity for listening

around chemistry. Using a variety c

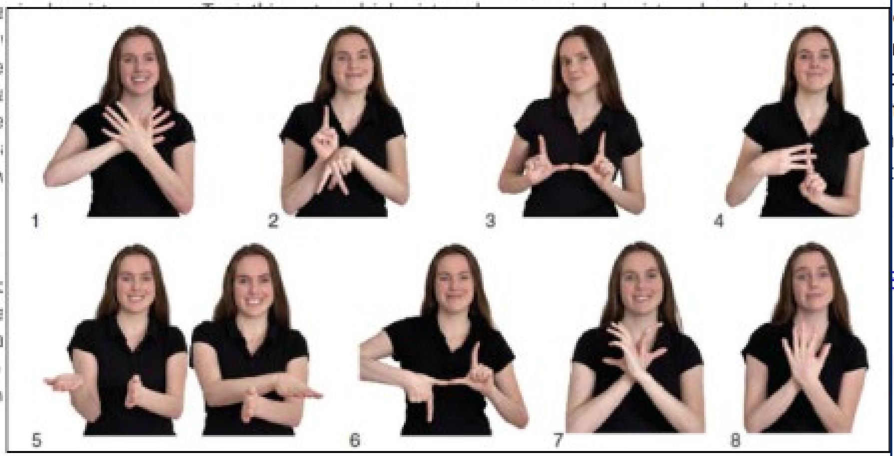
writing, speaking and listening—lea

because we are engaging different pa

Perhaps organic chemistry is the

language you are learning. Such is th

who read English and use American Sign Language (ASL) to communicate. ASL interpreters for science classes often have a hard time keeping up when they have to spell out unfamiliar words such as s-t-e-r-e-o-i-s-o-m-e-r. Spelling out words also disrupts the flow of the lecture for the learner. There is a growing need for signs that represent scientific terms, but the development process is a slow one. New signs must follow the linguistic rules of ASL, and they need to consider the context in which the term is used. The word "molecule" means different



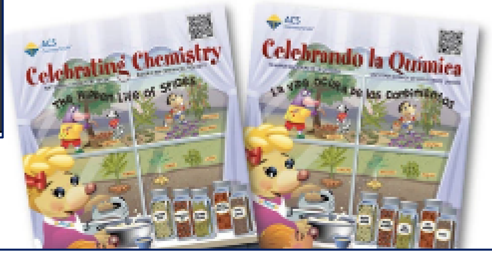
2025 The Hidden Life of Spices

ucational resources for this year's National Chemistry Week theme and other ls for your event, including outreach activities, articles, and videos.

NATIONAL CHEMISTRY WEEK

and identify how chemistry plays an essential role in spices. Learn more about mical properties that make up how we perceive spices. Spices are mixtures of als, with some notable chemicals involved, including capsaicin (makes peppers myristicin (makes smell and taste of nutmeg), and many more. The structural ces of these chemicals affect how spices taste and smell, while also allowing o be used as fabric dyes, medicines, and much more!

ebrating Chemistry (Ages 9-12)



Middle School (Ages 11-13)

From Middle School Chemistry

- Molecules in Motion

  Add food coloring to hot and cold water to compare the rate of mixing.
- Temperature Affects Density

  Use food coloring to find out whether hot water will sink or float when layered on top of cold water.

Thank you!

Any Questions?

lsstarkey@cpp.edu

O-Chem I

Syllabus

Organic Chem Teaching Resources

chemistryconnected.com

O-Chem I

Exam Wrapper