

FOUNDATIONS *to* FLUENCY

WITH **KLEIN ORGANIC CHEMISTRY**

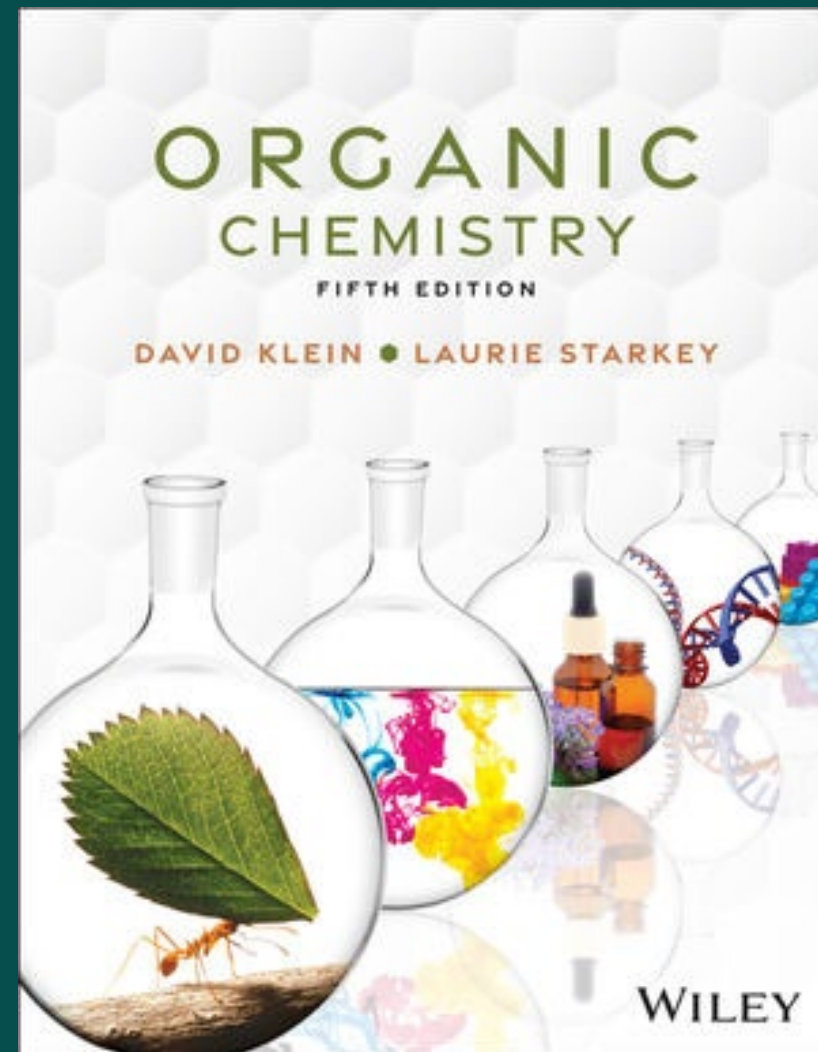
The Practice of Skill-Building: Connecting Pedagogy to Outcomes

1

Laurie Starkey
Cal Poly Pomona
Co-Author of
Organic Chemistry 5th Ed.

11:00 AM – 11:40 AM

WELCOME



About me...



Cal Poly Pomona

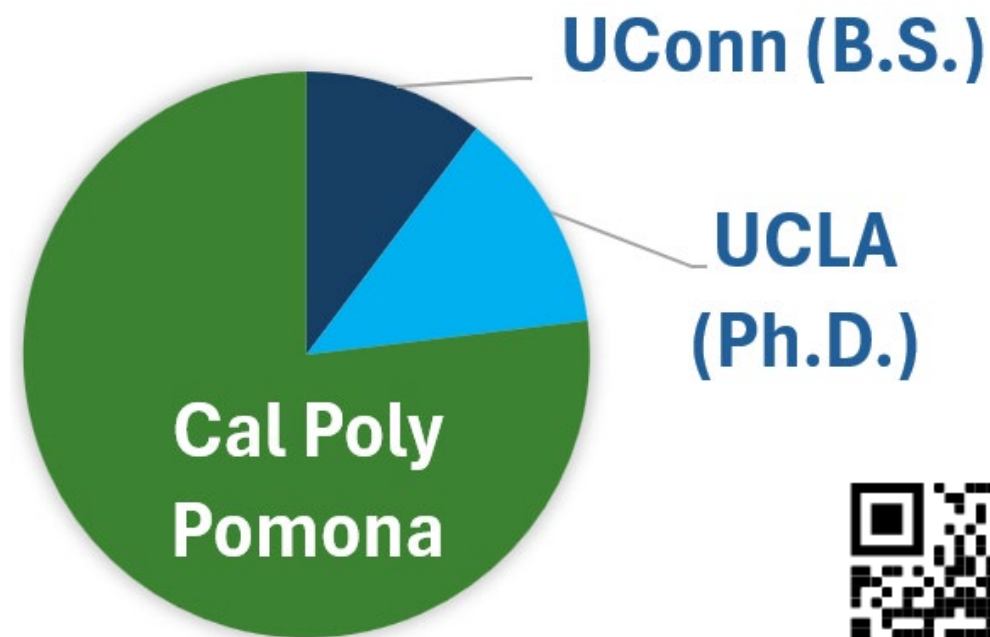
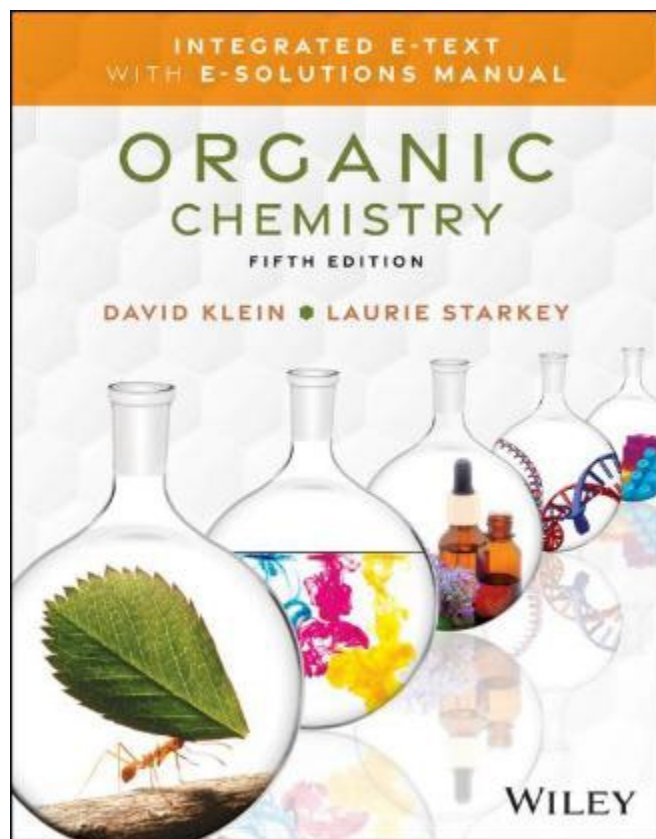
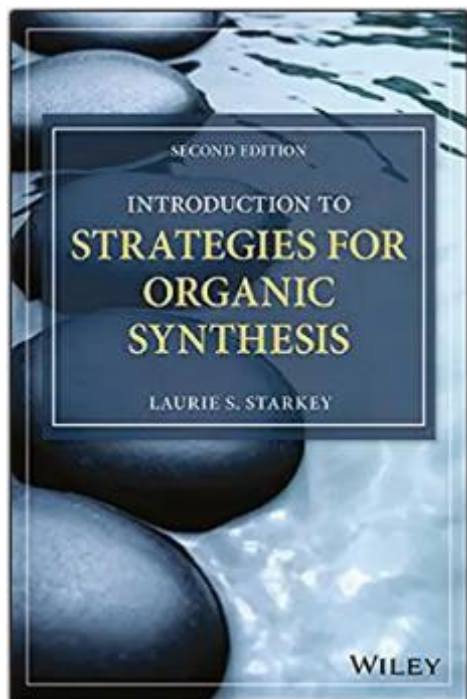
30 miles east of Los Angeles



**Est.
1996**



Felix Winkelkemper Wikimedia cc-by-2.0



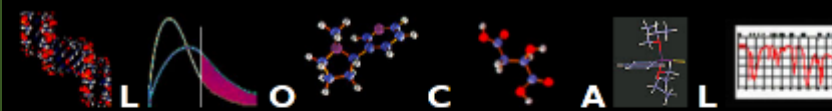
chemistryconnected.com



Resources for Teaching Organic Chemistry

O-Chem Active Learning Repository ChemistryConnected.com

- Clicker Questions
- Flipped Classroom Worksheets



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!) lstarkey@cpp.edu

Active-Learning Resources can also be found here: organicERs.org | MERLOT.org
see also: [student motivation resources](#)



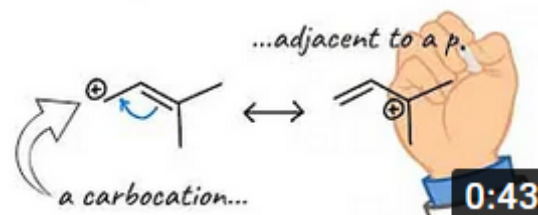
Stereochemical Relationships Practice Game

Three pairs randomly drawn for each [game](#) (Beginner or Challenging)

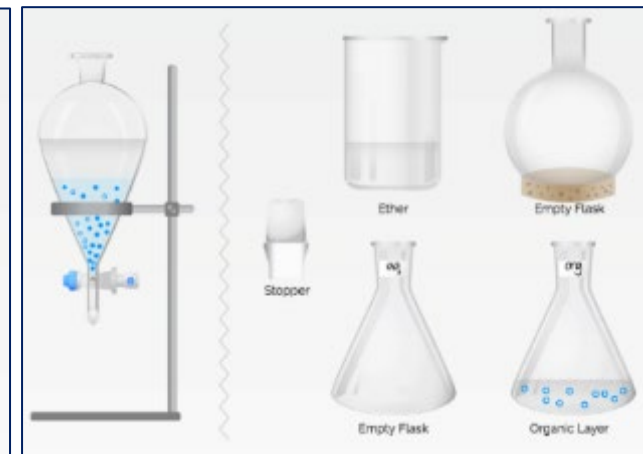
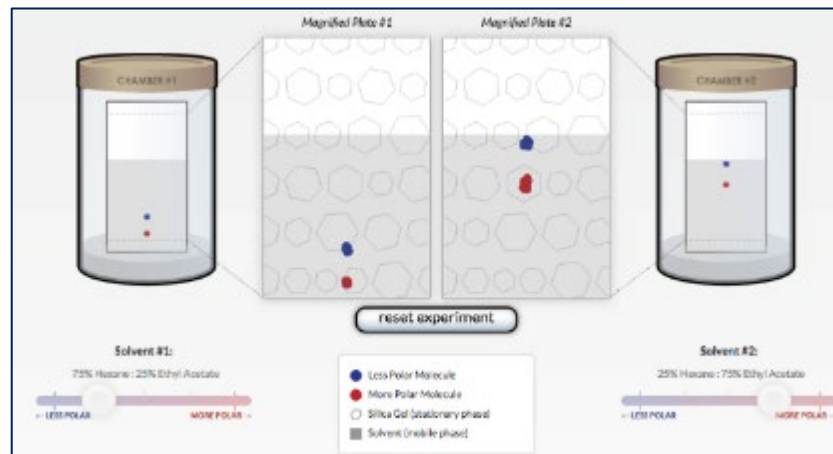
Clicker Questions:

Bonding/Structure, Acid-Base, Nomenclature Lewis Structures & Line Drawings Resonance & Hybridization (3-D) Acid-Base MO Theory Physical Properties Nomenclature Sites of Unsaturation (DU) Conformations of Alkanes & Cyclohexanes	Stereochem, Radicals, Study of Reactions Chirality & Optical Activity R/S, E/Z Nomenclature Stereochemical Relationships Radical Reactions Thermodynamics, Kinetics & Reaction Coordinate Diagrams	Substitution & Elimination Alkene/Alkyne Reactions Substitution Reactions (S_N1/S_N2) Elimination Reactions (E1/E2) Substitution vs. Elimination Dehydration of Alcohols Alkene Additions and Oxidation Alkyne Reactions Synthesis Strategies (Klein Ch. 11)	Alcohols, Ethers & Epoxides Alcohol Reactions Grignard & Hydride Reagents Epoxide & Ether Reactions Alkoxides & Thiols Syntheses Involving Alcohols
Carbonyl Chemistry Aldehydes & Ketones	Alpha-Carbon Chemistry Enols & Enolates	Conj. Systems, Aromaticity Conjugated Dienes (Diels-Alder, 1,2/1,4-	Additional Topics Amine Reactions & Synthesis

Resonance Patterns: Allylic Carbocation



Animations [TLC](#) & [Extraction](#)



Resonance Review

<https://www.youtube.com/chemistryconnected>

To Master a Challenging Skill: “Learn by Doing”

Success in Organic Chemistry requires...

- **Training** (Lecture, videos, student-friendly textbook)
- **Daily Practice** (Worksheets, tons of textbook problems)
- **Coaching** (Office hours, study groups, SkillBuilders)
- **Feedback** (Quizzes & exams, homework, WileyPLUS, Student Solutions Manual/SSM)

Practice makes ~~perfect~~ permanent



“Learn by Doing” in the Classroom

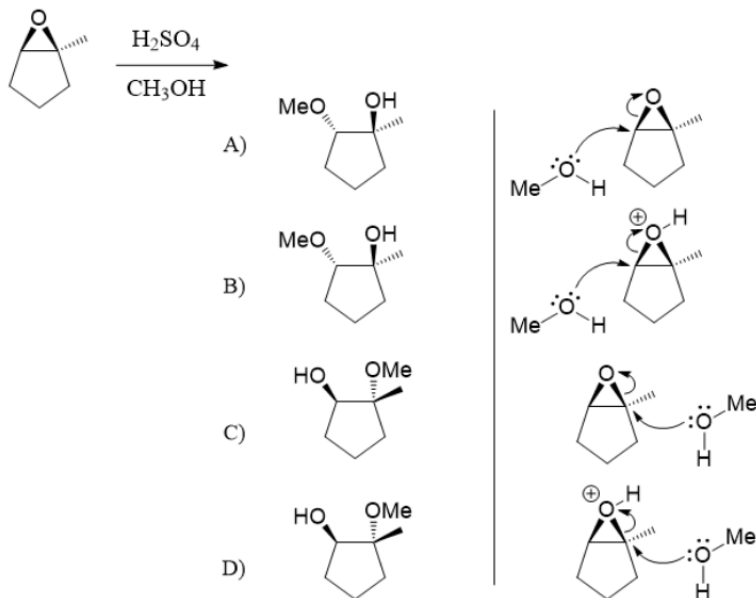
An engaged student is an active participant

- Socratic approach (Acidic or basic? Likely 1st step?)
- Ask for help, make intentional mistakes
- Put students to work (predict, add curved arrows)
- Clicker questions & discuss with a neighbor
- ~~Do you have any questions?~~ Ask me a question.

"Learn by Doing" with Worksheets

- Model problem solving
- Demonstrate tips/tricks
- Clicker questions (common mistakes)

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



CHIM 3150 Organic Chemistry II

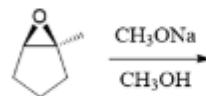
Dr. Laurie S. Starkey, Cal Poly Pomona

Chapter 13 Ethers & Epoxides Part 2 – Practice Problems

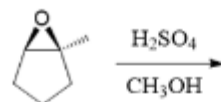
For clicker question voting, go to:
<https://polllev.com/lauriestarke263>



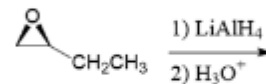
1 Predict the major product, and draw the mechanism.



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.

H₂O

NH₃

A) H₂O is the stronger acid because HO⁻ is **more** stable than H₂N⁻.

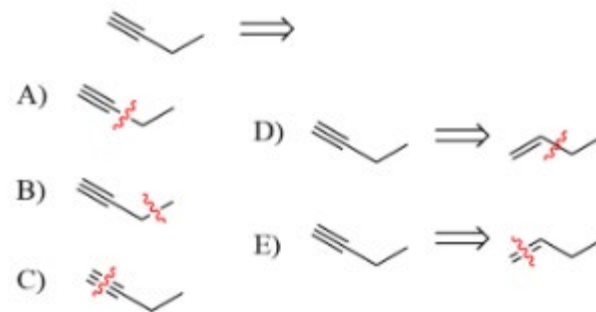
B) H₂O is the stronger acid because HO⁻ is **less** stable than H₂N⁻.

C) NH₃ is the stronger acid because H₂N⁻ is **more** stable than HO⁻.

D) NH₃ is the stronger acid because H₂N⁻ is **less** stable than HO⁻.

Try SkillBuilder 13.5

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



“Learn by Doing” using a Textbook

Hours Spent on Chemistry per Week

■ In class

■ Independent work



- Embedded practice: Read, **Apply**, Repeat...
- In-Chapter (baby steps): “Conceptual Checkpoint” problems, “SkillBuilder” modules
- End-of-Chapter (exam review): Practice problems, ACS-Style, Integrated, Challenge problems

SkillBuilders = Learn by Doing

LEARN the Skill

*a worked example
(solved problem),
with a summary of
the steps involved*

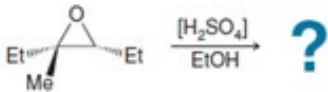
SKILLBUILDER



13.5 DRAWING A MECHANISM AND PREDICTING THE PRODUCT OF ACID-CATALYZED EPOXIDE RING OPENING

LEARN the skill

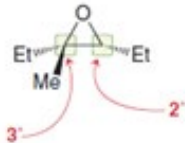
Predict the major product of the reaction below and draw a likely mechanism for its formation:



SOLUTION

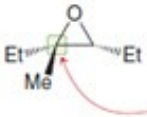
The presence of sulfuric acid indicates that the epoxide is opened under acid-catalyzed conditions. In order to draw the product, we must consider the regiochemistry and stereochemistry of the reaction.

To predict the regiochemical outcome, analyze the epoxide.



One side is tertiary, so we expect that electronic effects will control the regiochemistry, and we predict that nucleophilic attack will occur at the more substituted, tertiary position.

Next identify the stereochemical outcome. Look at the center being attacked and determine if it is a chiral center. In this case, it is a chiral center, so we expect backside attack of the nucleophile to invert the configuration of that center:



This chiral center will be inverted as a result of backside attack

STEP 1

Identify the regiochemistry by determining whether steric or electronic effects will dominate.

STEP 2

Identify the stereochemistry by determining if the nucleophile attacks a chiral center. If so, expect inversion.

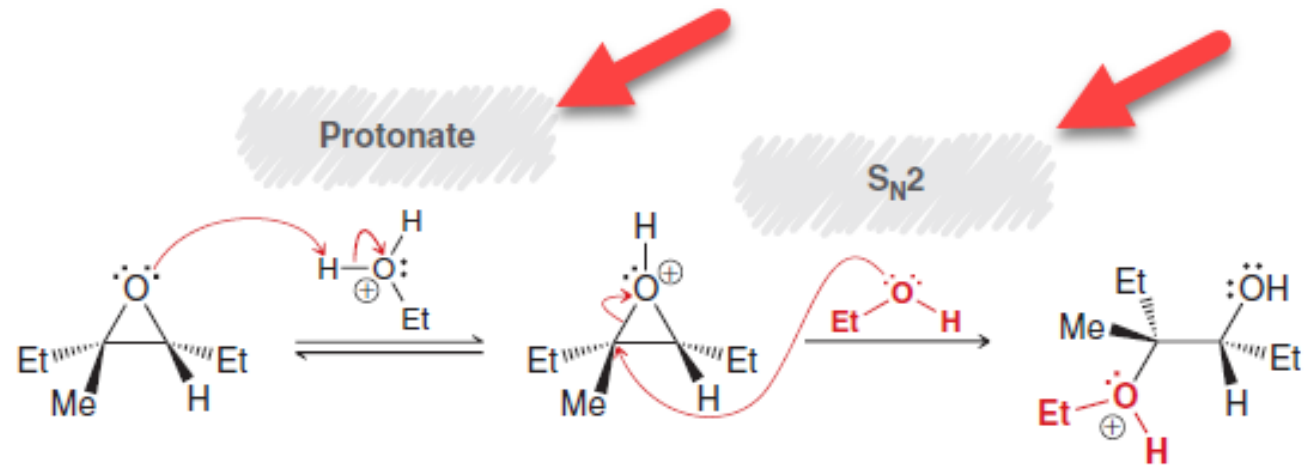
SkillBuilders = Learn by Doing

P.A.D. pattern

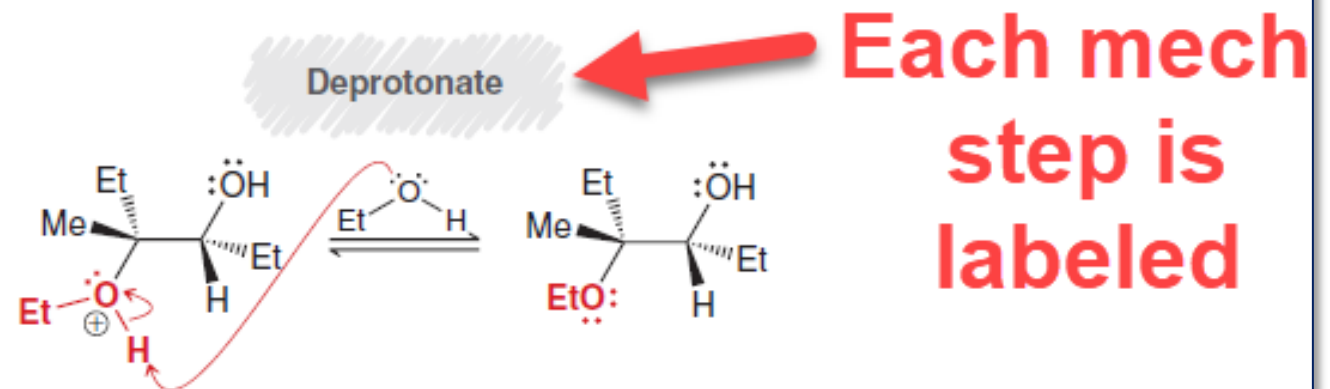
STEP 3

Draw the mechanism. If the nucleophile is H_2O or ROH , the mechanism will be three steps (P.A.D. pattern).

Now that we have predicted the regiochemical and stereochemical outcomes, we are ready to draw a mechanism. The epoxide is first protonated and then attacked by a nucleophile (EtOH):



Since the attacking nucleophile was neutral (EtOH), the mechanism must include an additional deprotonation step to remove the charge and generate the final product.



If we want students
to *think* and *solve*
problems, training
is needed!

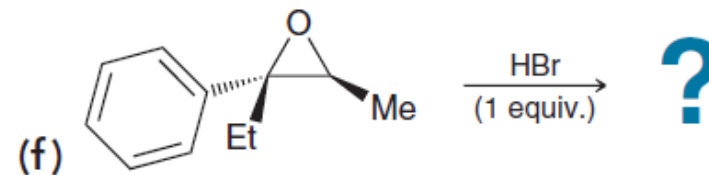
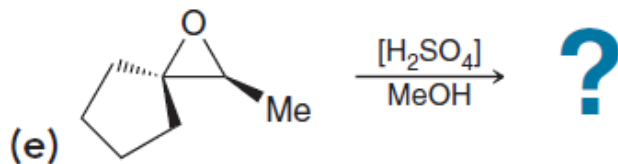
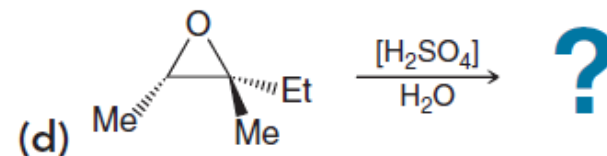
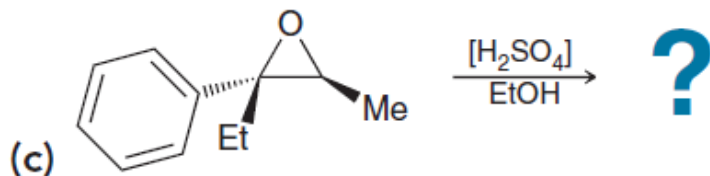
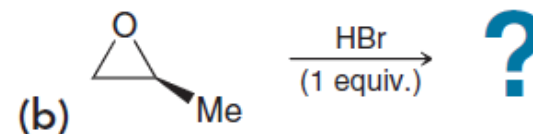
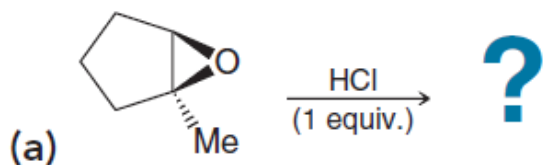
SkillBuilders = Learn by Doing

PRACTICE the Skill – *several practice problems for students to try on their own*



PRACTICE the skill

13.17 For each reaction, predict the major product and draw a mechanism for its formation:

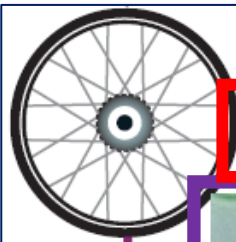


SkillBuilders = Learn by Doing

APPLY the Skill – *literature-based “real world”*

application of the skill being learned

5. J. Org. Chem. 1991, 56, 3814–3817.



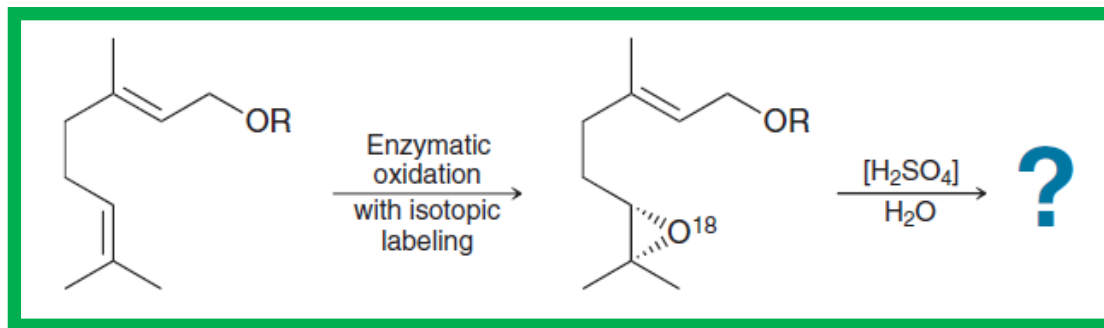
APPLY the skill

Photo and caption highlight purpose and relevance of material



The microbe *Aspergillus niger* is responsible for black mold. It can also be used to catalyze enantioselective oxidations in the laboratory.

13.18 The sequence below shows an enantioselective synthesis of a diol that is achieved via two sequential reactions: 1) asymmetric biooxidation (in the presence of enzymes, nature's catalysts) to give a chiral epoxide, followed by 2) a ring-opening reaction. To study the mechanism of this process, isotopically labeled molecular oxygen, $^{18}\text{O}_2$, was used for the oxidation reaction, forming the labeled epoxide shown.⁵ Draw the expected product of the epoxide ring-opening reaction, and show a mechanism for its formation, clearly indicating where the ^{18}O atom would be found in the diol product.



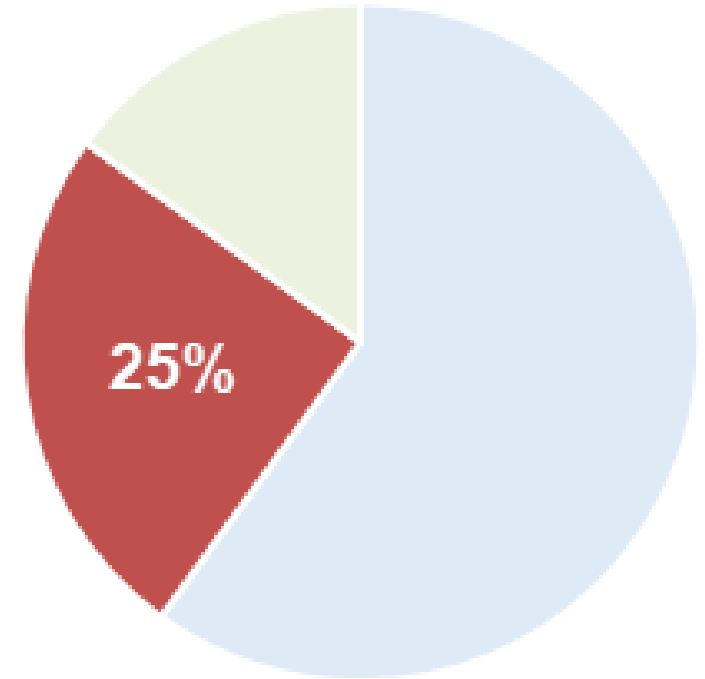
Literature citation

Extends skill to a more complex example

need more **PRACTICE**? Try Problems 13.38d, 13.39c, 13.42d,e, 13.47, 13.53, 13.55, 13.66

“Learn by Doing” using a Textbook

- Textbook Problems = Formative Assessment
- Encourages self-assessment and use of Solutions Manual
- 25% of course grade based on In-Chapter (SkillBuilders) and/or End-of-Chapter Problems



■ Exams ■ Homework ■ Reflection

Course Credit for Practice Problems

If you value it, assign points to it...and then *students value it!*

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)

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.

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.*



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

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.

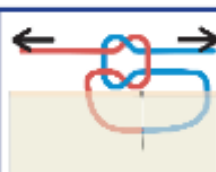
Suggested Ch. 20 problems *Mechanisms and **Synthesis (good to work on by hand)

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.



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

Why I Use Online Homework (WileyPLUS)

- Do we want students to work on **textbook problems** for practice?
- How do we **provide support** to facilitate this work?
- Ideally, **24/7 coaching and feedback** is not needed from professor!
- Assign **SkillBuilder modules** (Learn/Practice/Apply the Skill)

Here's your book.
Good luck!

First 20 years of my teaching career

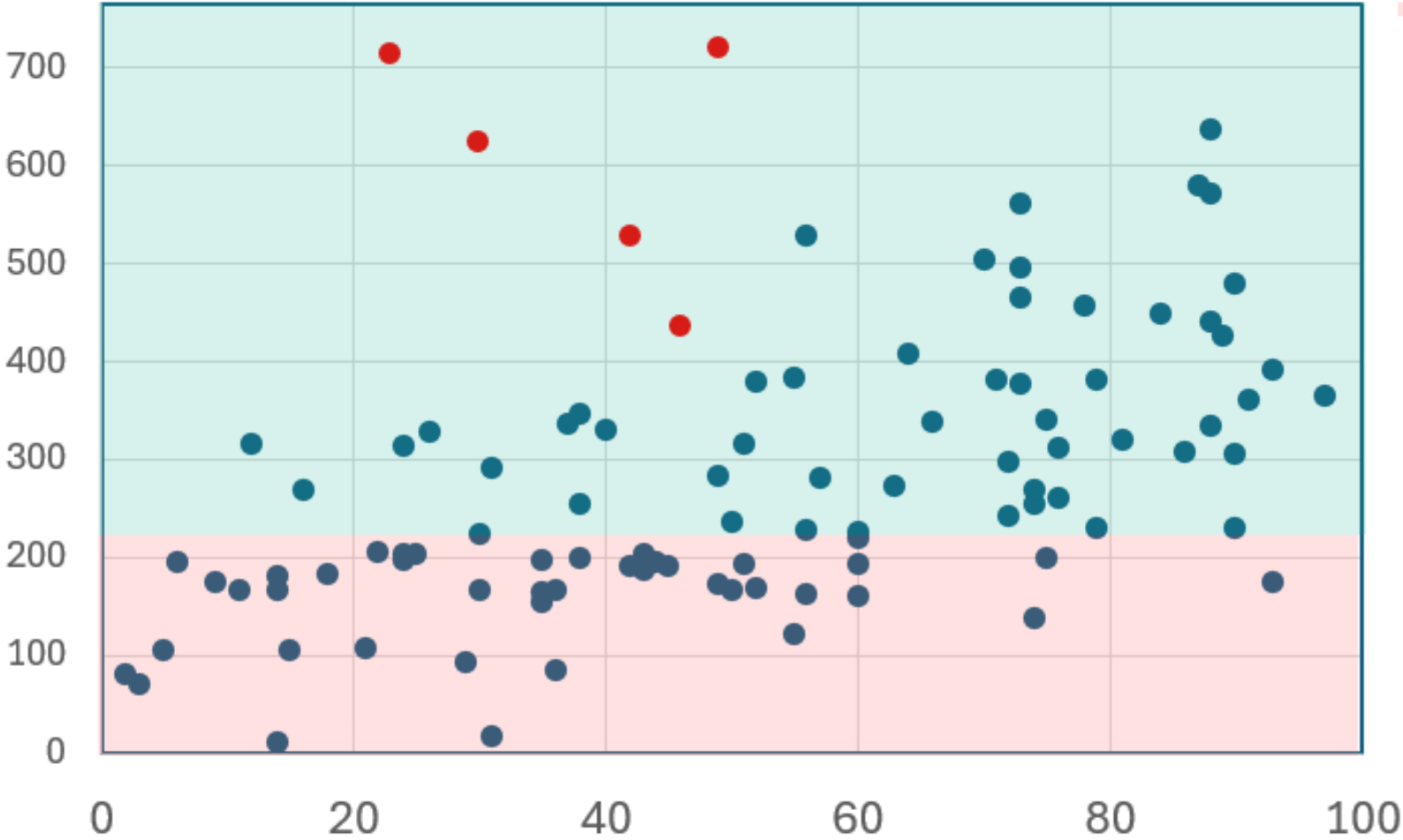


dreamstime

Effectiveness of WileyPLUS

Fall 25 (n=101)

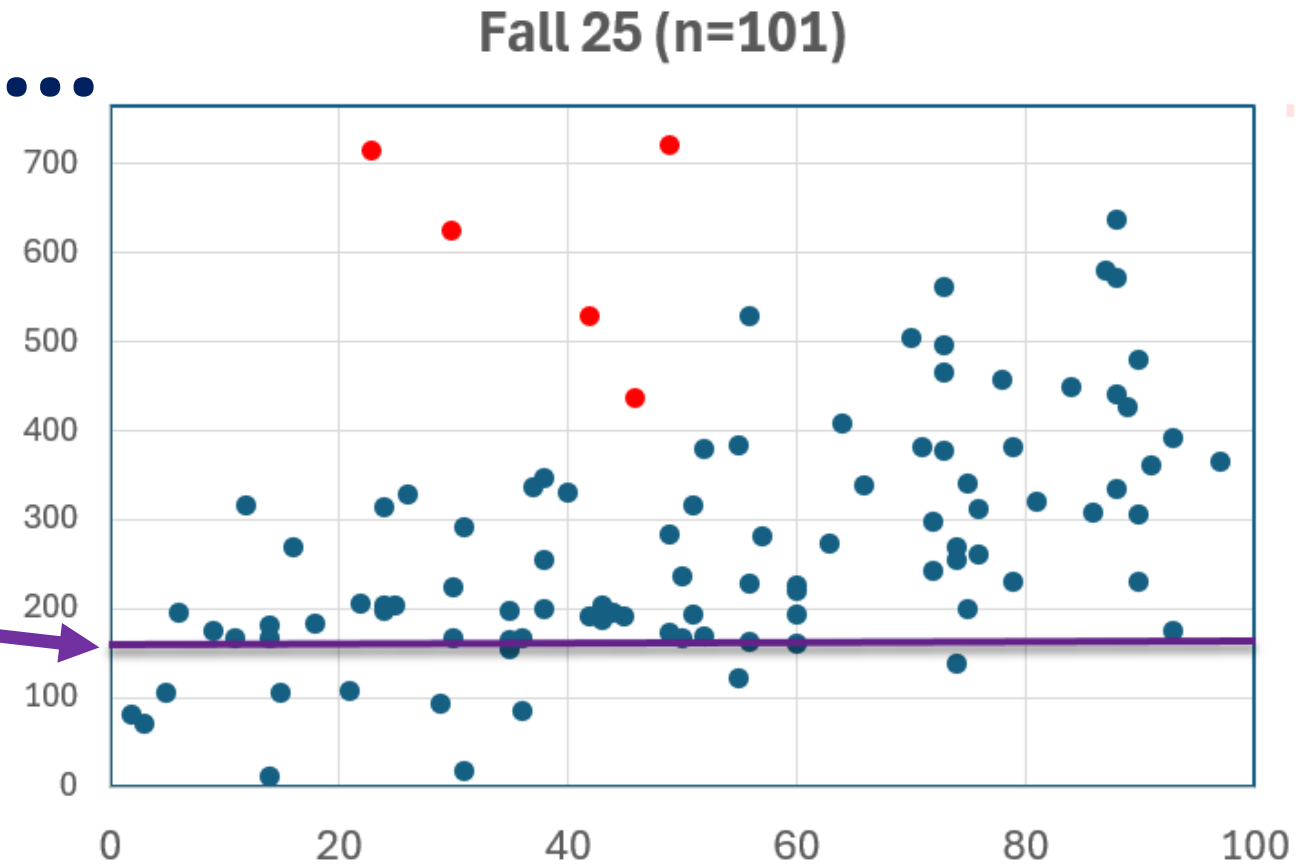
WileyPLUS
points earned
(max. = 750)



Exam 2 Score

Why I Use WileyPLUS...

Most students did far more problems than min. required for credit (160 pts)



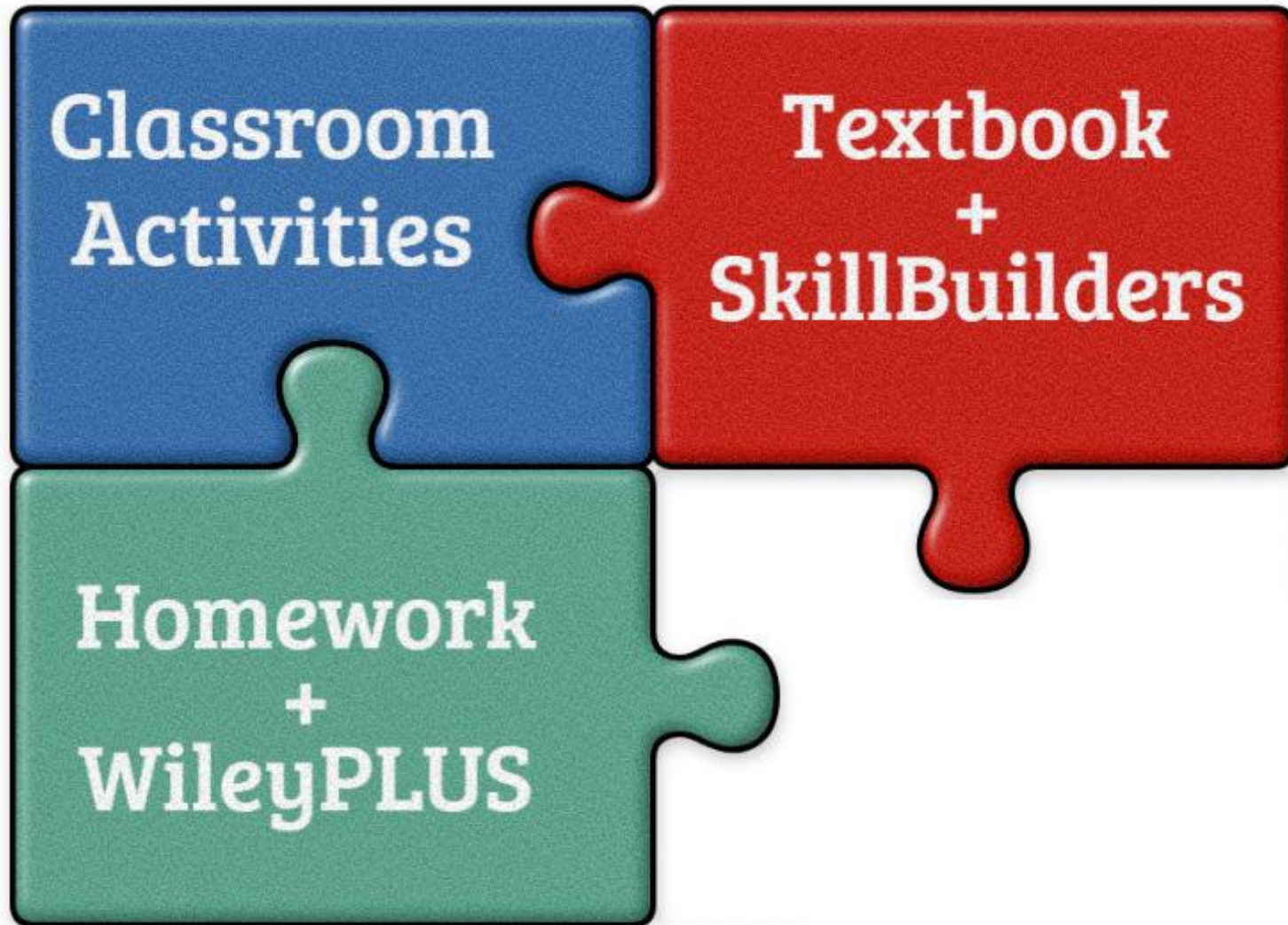
Positive WileyPLUS
experience

Positive experience
for Professor

Student does
more homework!

Many tools for success...

...but something is missing!



Why is *Motivation* Critical to Success?

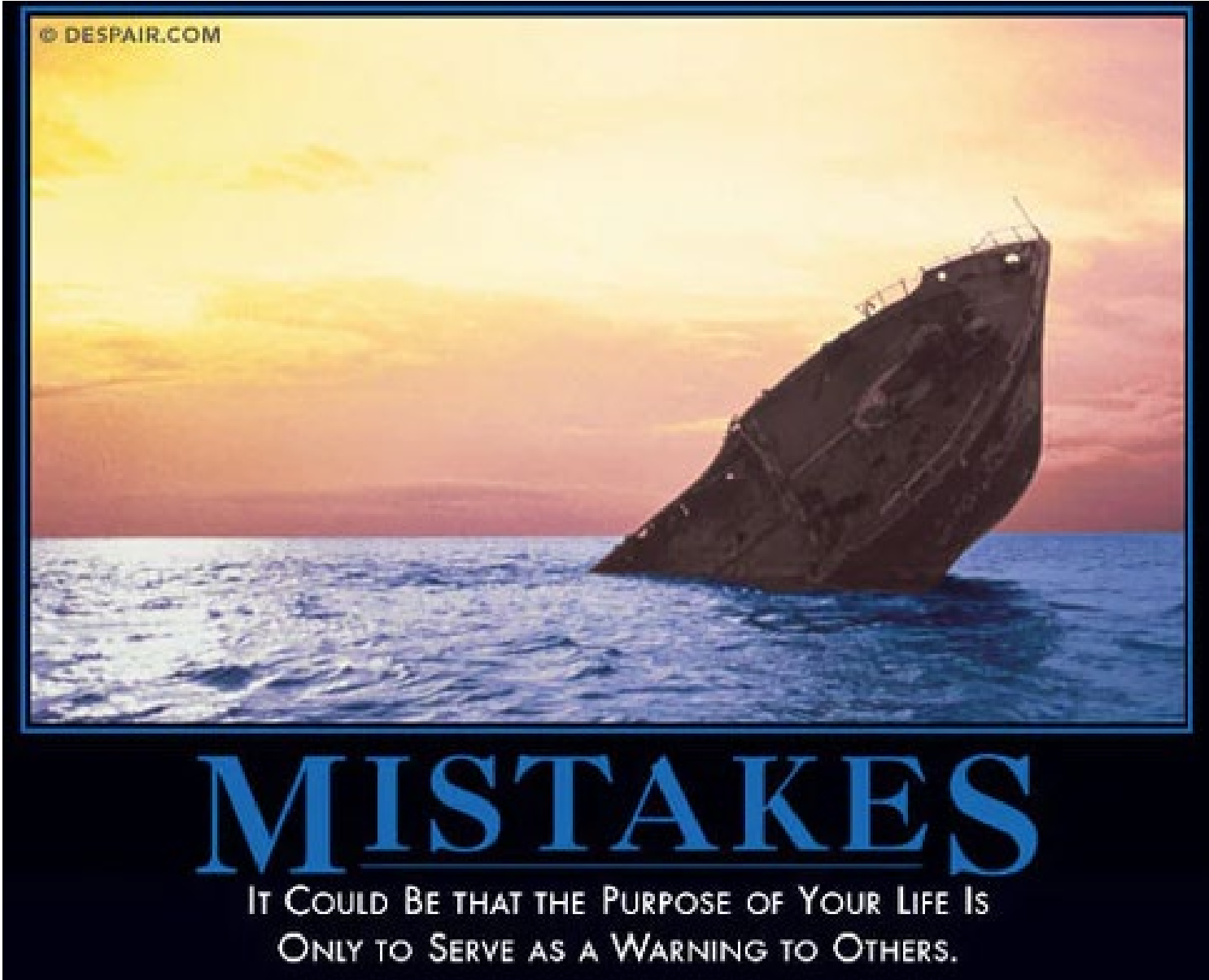


Because
**all growth
involves
discomfort**

To be successful, students must:

- Put in the required hours every day/week
- Keep working on challenging problems
- *Persist* after facing setback(s)

What Motivates Students?



We can do
better than
relying on the
Fear of Failure...

Keeping Students Motivated (G.P.S.)

Motivate Lab training*

- ✓ **Growth Mindset**
- ✓ **Purpose & Relevance**
- ✓ **Sense of Belonging**

*Dustin Thoman
dthoman@sdsu.edu

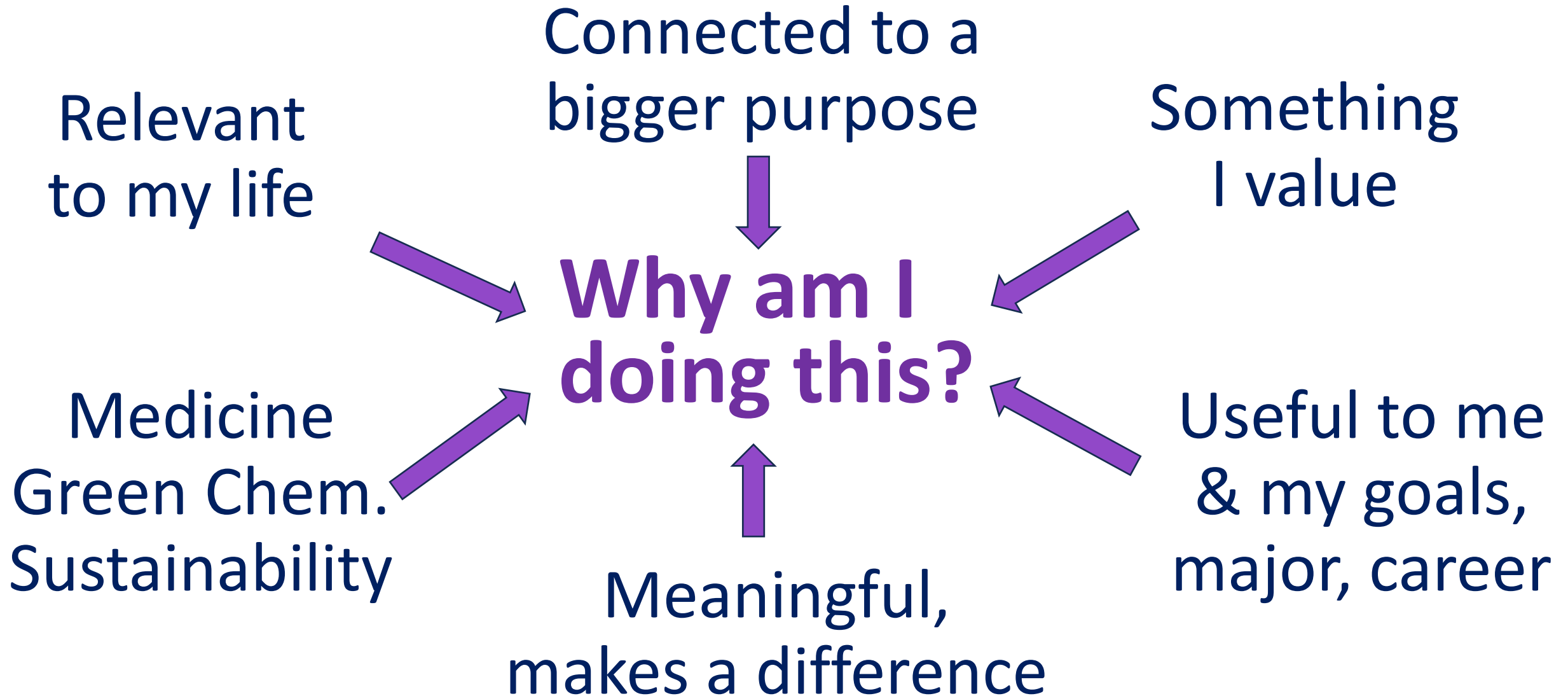
GPS: Encouraging a Growth Mindset

Don't praise *ability* – focus on *process*



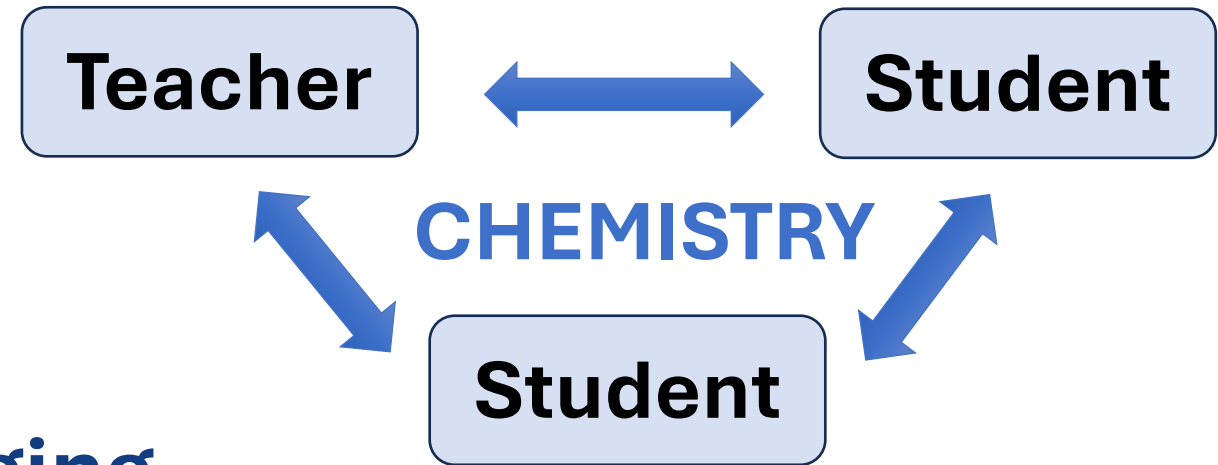
GPS: Focusing on Purpose and Relevance

#1 Motivator! Leads to persistence, deeper learning.



GPS: Build Community, **S**ense of Belonging

- ✓ Support learning by **building relationships**

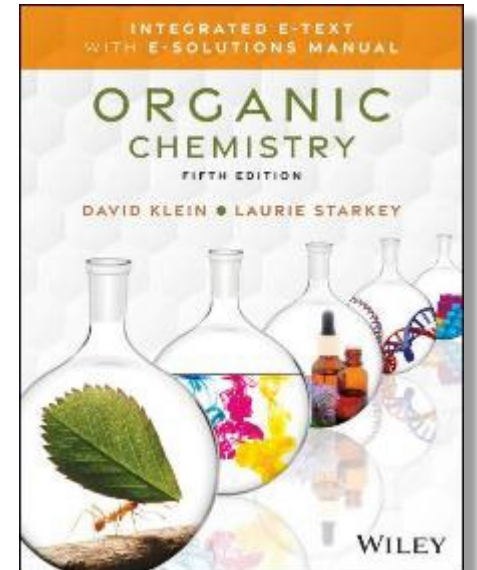


- ✓ Promote a **Sense of Belonging**
Do I belong in this class?
Am I the only one who is confused?
- ✓ Students who are **included** are open to critical feedback, can accept challenges & bounce back
- ✓ Critical for 1st generation (help close achievement gap?)

Can Motivational G.P.S. be Infused Throughout a Textbook? *I think so!*

1. Revisions based on **faculty feedback**
2. Revisions based on **teaching experience**
 - Reorganized content (logical, clear, efficient)
 - New SkillBuilders, problem-solving strategies
3. Revisions to increase **student engagement & motivation**
 - Study tips, hints, common mistakes
 - New applications and 400+ new graphics/images

Purpose – Relevance – Sense of Belonging



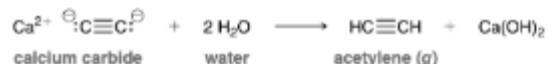
New WorldLink/BioLink Applications

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 last 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 in dangerous coal mines where pockets



WorldLinks Fragrances and Perfumes



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

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.

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 from the anal glands of civet cats,



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 with terpenes. You may have even seen a few examples of terpenes that are found in nature.

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



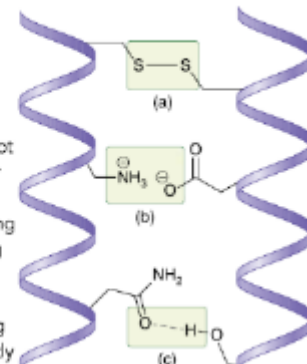
They can even be used as permanent make-up on the eyes and lips. Tattooing also serves as a way to restore features that were lost, such as a reconstructive breast surgery. Being of the patient can be in a realistic-looking areola. Likewise, for someone missing

synthetic fragrances were produced. With the tools of organic synthesis at their disposal, chemists design novel fragrances, and develop alternatives to products that fragrances are not only used to make perfumes and colognes (and air fresheners), but they are also added to many personal care and household

BioLinks Hydrogen Bonding and Bad Hair Days

Wavy or straight or kinky or curly—each person has a certain type of hair as it grows naturally. And naturally, it's

treatments, such as relaxers, straighteners and "perms" cleave the covalent S-S bonds and then



11.7 Natural Product Synthesis

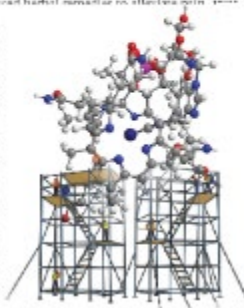


In a steam distillation, the essential oil of a plant is isolated as it co-distills with water.

"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 natural products to treat wounds and cure various ailments. Therefore, it makes sense to search for compounds that might have antibiotic properties. Natural product chemists do exactly that—they gather and isolate the organic components that are present in natural products. They can also be found in sea creatures and microorganisms. Organic compounds are isolated, their structures are determined using a variety of techniques such as IR and NMR spectroscopy. In some cases, the three-dimensional structure of a molecule can be determined by X-ray crystallography. Any novel compounds that are identified can then be synthesized.

Recall from the WorldLink lesson on terpenes in Chapter 11 that terpenes are a class of natural products. Known as secondary metabolites, they are not directly involved in the growth and development of the plant.



tattoo design is often passed down through generations. It is traced over centuries and is often a source of pride. In the past, tattoos were often used as a form of identification. In the modern world, tattoos are often used as a form of self-expression. Tattoos can be permanent or temporary. Temporary tattoos are often made from a special ink that fades over time. Permanent tattoos are made from a special ink that lasts for a lifetime. Tattoos can be made on any part of the body. They can be made in a variety of colors. They can be made in a variety of shapes. They can be made in a variety of sizes. They can be made in a variety of ways. They can be made in a variety of places. They can be made in a variety of times. They can be made in a variety of ways. They can be made in a variety of places. They can be made in a variety of times.



Structural Color

The color wheel demonstrates the complementary relationship between the wavelengths of visible light that are absorbed and those that are reflected. But how do the iridescent colors in bird feathers work? Why would a color ever change based on your viewing angle?

The ability of bleach to remove colors was described in the previous WorldLinks application: when a π bond in a chromophore undergoes a chemical reaction (e.g., an addition or oxidation reaction) the conjugated π system is disrupted, and colors can disappear. Upon exposure to sunlight, the colored fabric on outdoor furniture usually fades over time, so how does a lizard keep its brightly colored skin from being "bleached" by the sun?

The secret behind these brilliant and beautiful colors is that they do not arise from absorption of light or electronic transitions. Rather than being produced by a pigment molecule, iridescent colors are produced by the interaction of light with the microscopic structure of a surface. As the light hits various structural features, such as thin films or nanoscale-sized parallel grooves, it undergoes diffraction (in other words, it separates). When the diffracted light waves recombine in various ways, they create new colors. Structural coloration is



Fear of Failure For the Love of Chemistry...

Accessible

7 Former organic chemistry student and future Physician Assistant Christina Gloady is proficient in both the language of chemistry and American Sign Language (ASL).

8

Throughout the ages, humans have had to cope with seasickness and erectile dysfunction. In the 21st century, we have drugs to treat both, thanks to accidental discoveries.

Fragrant materials filled the beaks of masks worn by plague doctors

Azulene, a deep blue liquid, is often included in hair-removal waxing kits. It is an effective solvent for removing residual wax.

Food Science 411: enology is the science of making wine, and viticulture is the study of grape production.

Klebsiella bacteria contribute to infections acquired by hospital patients. The ability of microorganisms to develop resistance to antimicrobial drugs means pharmaceutical research will be ongoing forever.

Cadaver dogs can help find victims of natural disasters and victims of foul play. They can also help marginalized communities by locating unmarked burial grounds for early Indigenous or enslaved people.

When preparing a refreshing drink, a muddler tool is used to crush mint leaves and release their essential oils.

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

Interesting

The distinctive horn of the rhinoceros is composed primarily of keratin. Although rhino horn is no more special than your fingernails, it is ground into a powder and used in traditional Chinese medicine, and rhino horn products are viewed as luxury items and status symbols in Vietnam. The illegal but lucrative sale of rhino horn to Asian markets has fueled poaching and endangered the species.

Green Chemistry

A creative rendition of a crazy ant, armed and ready to battle fire ants.

The arrowhead on a fishhook arrow resembles the barb on a fish hook.

It is derived from the German word for peppermint (Pfefferminz), the original flavor of the product. In 1927 as an alternative to smoking, in 1928, the iconic 807 cigarettes were created.

Better sleeping through chemistry, thanks to "waterlock" powder (sodium polyacrylate) in Baby's diaper.

Don't pick the dandelions! Like heather, these flowers have anti-parasitic chemicals that keep pollinators healthy.

Don't kiss the frogs! The poison-dart frog produces a deadly toxin.

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

Favorful lemon zest, taken from the rind of a lemon, contains the fruit's essential oil.

HELLO my name is
Grignard reagent
RMgBr
New graphics to call out "Name Reactions"

Aspirin is a non-steroidal anti-inflammatory drug (NSAID). It was synthesized by a chemist at Bayer in 1897. The ancient Romans used its precursor (found in willow tree bark) to relieve pain over 2000 years ago! The Bayer logo is derived from the New Orleans Pharmacy Museum.

On average, Americans consume 17 teaspoons of added sugars per day - about 1/3 cup! If you use an artificial sweetener as a sugar substitute, it can help reduce your calorie intake.

Motorcycle helmets are constructed from strong materials such as polycarbonate polymers and Kevlar.

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

Inclusive

pentanoic acid
Contributes to the odor of a cheetah's territory-marking spray

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

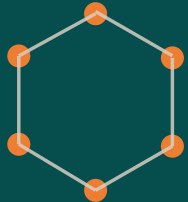
Study Tip

The larvae of dermestid beetles feed on decaying flesh, so these beetles can be used to clean bones for taxidermy purposes. If such larvae are on a corpse, they might help a forensic investigator.

Epoxy resins are used to make art.

Activated composite (te) materials are used for filling cavities.

Poly(vinyl chloride) is also known as PVC or simply "vinyl." It is used to make pipes for plumbing, albums, inflatable toys, decals, material for shoes and upholstery, medical tubing, vinyl siding for home exteriors and vinyl wraps for vehicle exteriors.



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QUESTIONS & DISCUSSION

**Drop your question in the
chat or unmute to ask.**

