Encouraging Students to Make Connections between Course Concepts and Real-World Applications

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The University of Toronto

July 2015

Chemistry
UNIVERSITY OF TORONTO

Department of Chemistry at the University of Toronto

The Department of Chemistry is dedicated to providing an exceptional education for all of our students by implementing innovative teaching methods in the classroom and laboratory.

Lash Miller Building
(St. George Campus)

www.chem.utoronto.ca

University of Toronto – Undergraduate Chemistry

Organic Chemistry II

The U of T second year organic chemistry courses focus on organic reactions, mechanisms and synthetic applications (pre-requisite: one semester of organic chemistry).

CHM247H
Designed for life-science students (1100+ students over 3 semesters)

or

CHM249H
Designed for students with a passion for chemistry (70-80 students in one term per year only)

Who is Taking CHM247H: Organic Chemistry II?

Most students in the course are…

- Bound for professional school (medical, dentistry, pharmacy, etc.)
- Are taking the course as a pre-requisite for their program
- Are motivated to earn an exceptional grade in the course
- Have a preconceived notion that the course is going to be extremely difficult
- Do not think that organic chemistry is relevant
- Not thinking of pursuing organic chemistry further

My Teaching Goals

1. Teach with Clarity
2. Encourage Critical Thinking and Problem Solving
3. Create a Positive Learning Environment
4. **Connect Course Concepts to Real-World Applications**

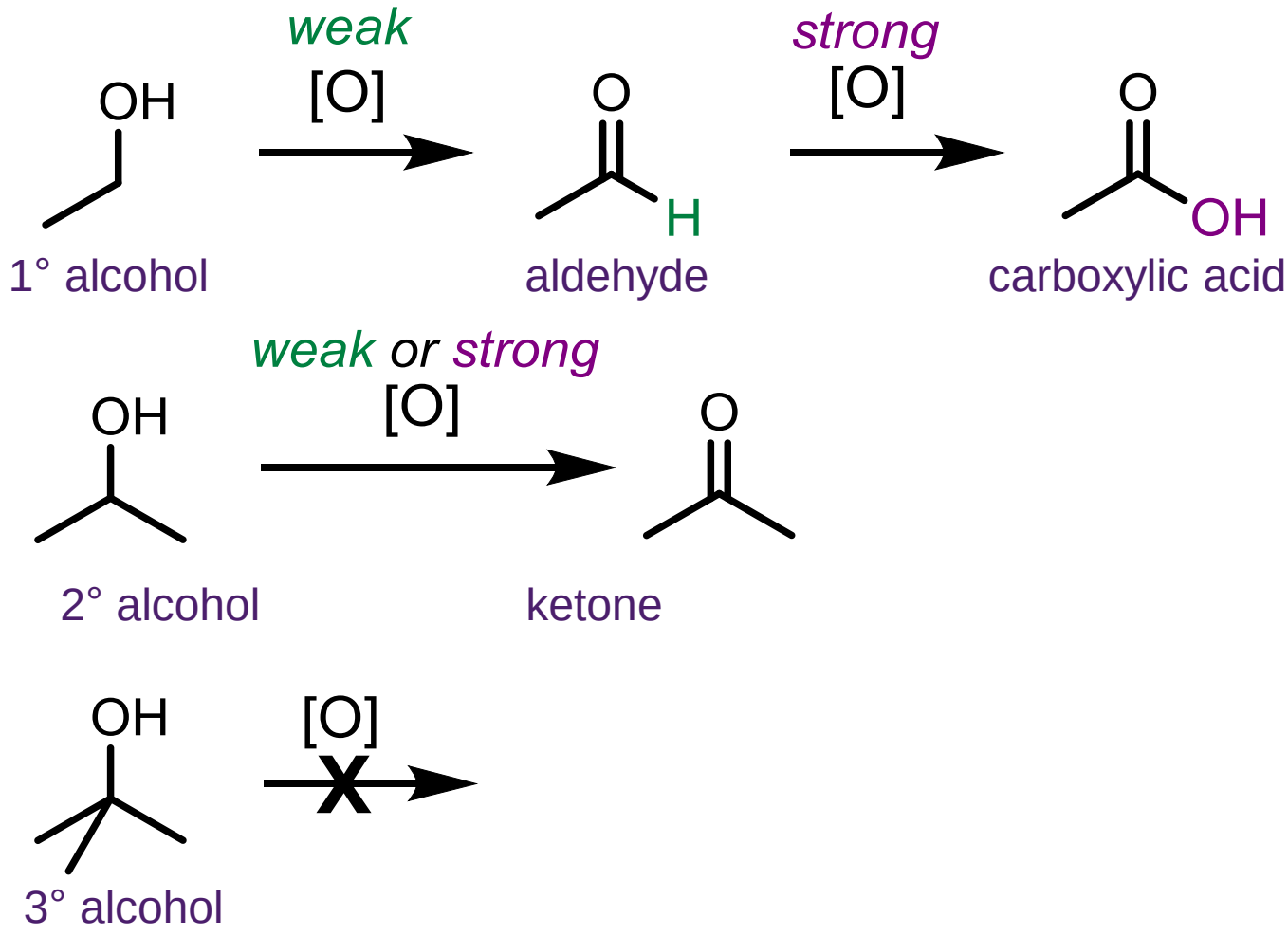
   Chemistry Connections Slides:

   Throughout each lecture, I incorporate real-world examples that highlight interesting applications of the lecture material in one complete slide. These examples bring the topics to life and promote interest in the course content.

   Let's look at some examples…

Oxidation of Alcohols

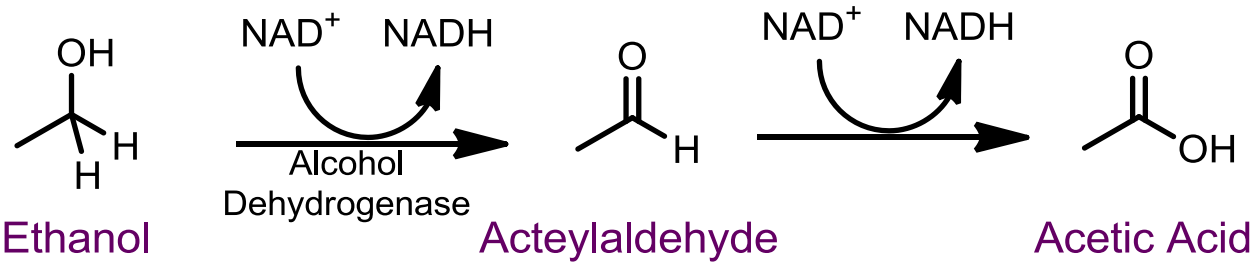
Alcohols (1°/2°) can be easily oxidized to carbonyl groups:



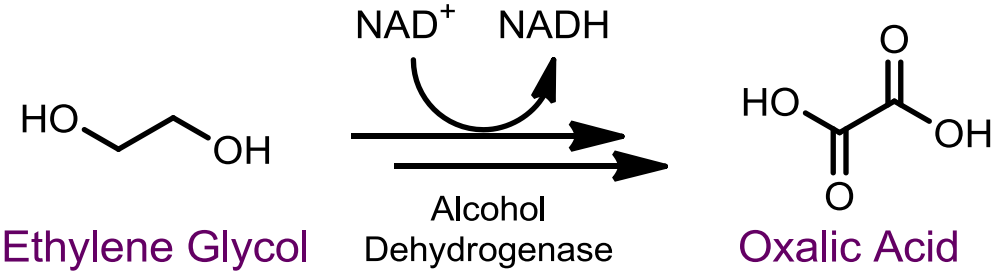
Chemistry Connections

Biological Oxidation of Alcohols

- Primary alcohols (like ethanol) are oxidized twice in our bodies:

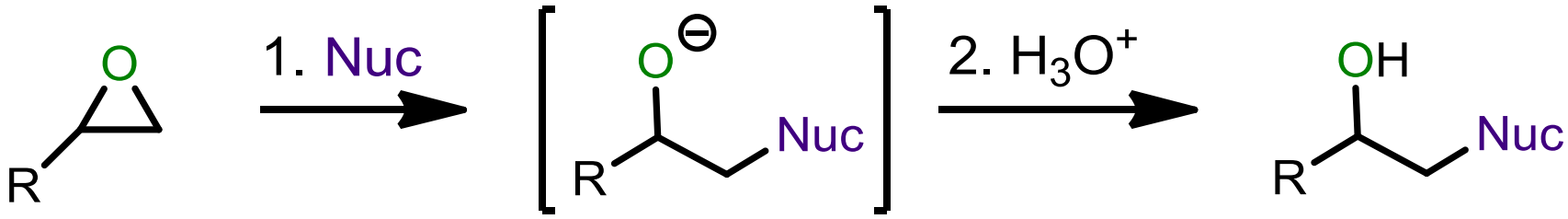


- A build-up of acetaldehyde and acetic acid causes nausea, vomiting, headache and fatigue (aka: a hang-over).
- Ethylene glycol (antifreeze) is metabolized into oxalic acid which is highly toxic. An overdose is treated with EtOH, which has a 100x greater affinity to the enzyme, blocking its degradation.



Nucleophilic Epoxide Opening

Epoxides can be cleaved with nucleophiles which attack the least substituted carbon with inversion of stereochemistry (S_N2):

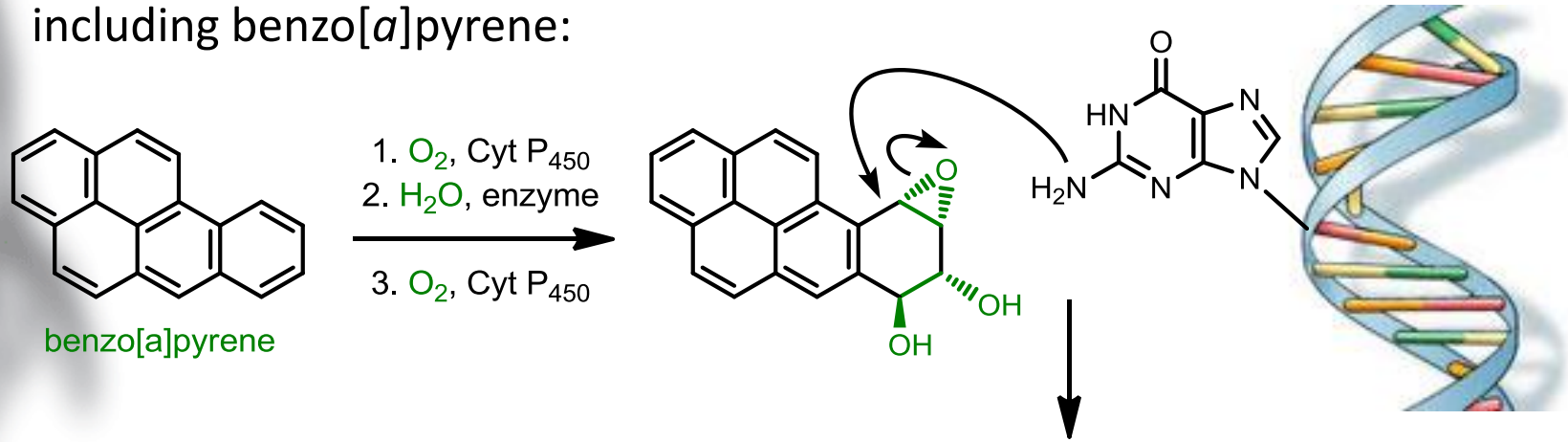


Nuc: RO^-, RMgX, RLi, RNH_2/R_2NH, ^-CN, ^-SR, $RC{\equiv}C^-$, $LiAlH_4$

Chemistry Connections

Cigarette Smoke and Carcinogenic Epoxides

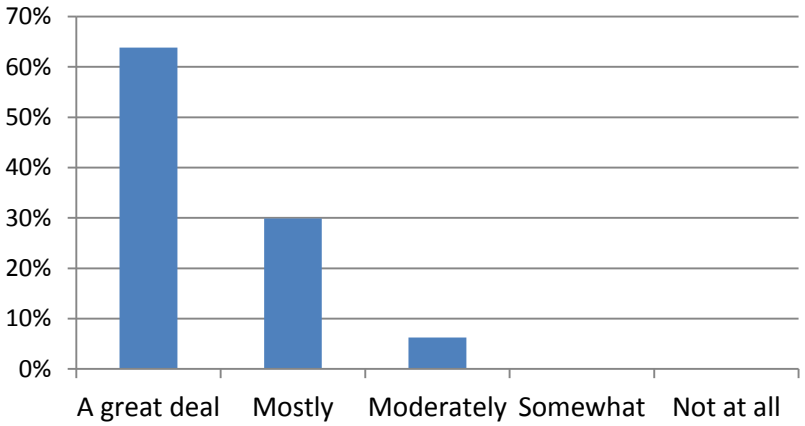
- Incomplete combustion of tobacco and other organic materials in cigarettes leads to the formation of many carcinogenic compounds including benzo[*a*]pyrene:



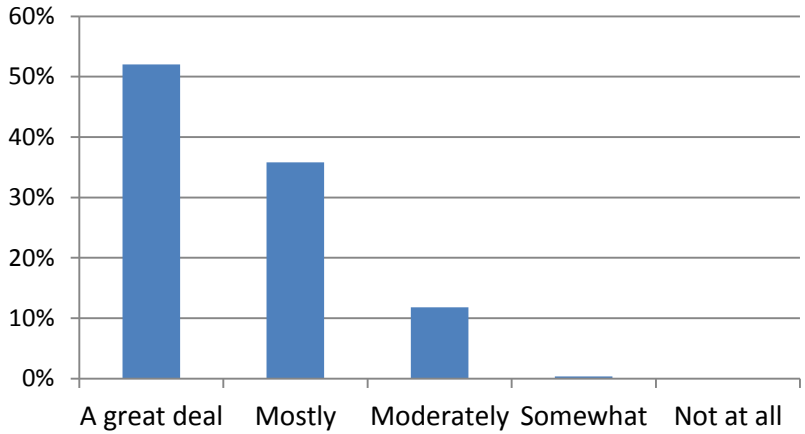
- When benzo[a]pyrene is metabolized, it undergoes 2 epoxidation reactions.
- After one is opened with H_2O, it then alkylates DNA, which disrupts regular function and leads to cancer cells.

Chemistry Connections Student Feedback

The Chemistry Connections slides stimulate new ways for me to think about organic chemistry and how it is applied in nature, research, and/or everyday life.



The Chemistry Connections slides inspire me to learn more about organic chemistry.



Select Student Comments:

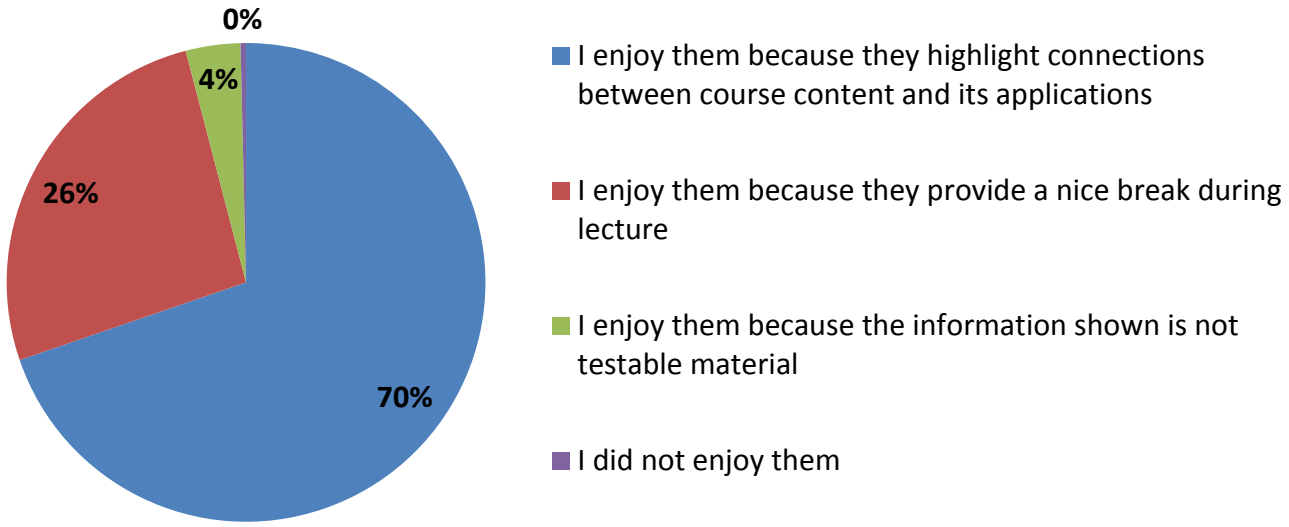
"Chemistry connection slides are really beneficial to my learning because they keeps me engaged in class and prompt me to think about real-life applications of lecture material. It provides a deeper purpose to learning organic chemistry and adds to my general knowledge."

"Chemistry connections slides really inspire me to learn more about organic chemistry."

"The chemistry connections were really fun and gave me a greater appreciation for organic chemistry as I now see that it applies to practically every aspect of our lives!!!!"

Chemistry Connections Student Feedback

Which statement best describes your opinion of the Chemistry Connections slides in class?



Select Student Comments:

"Chemistry Connections slides brings chemistry to life!"

"Chemistry is cool, but chemistry connections are cooler! It can be hard to see how the things we learn in the classroom relate to the 'real world' and I think these slides do an awesome job of reminding us that there's more to school than exams and grades. I love that some lecture time is spent on interesting material just for the enjoyment of learning."

Chemistry Connections Challenge!

Students who enjoyed the *Chemistry Connections* slides in class were given an opportunity to create and share their own!

Optional Assignment Overview

Assignment: 1 Chemistry Connections slide

Timeframe: last 6 weeks of the course

Rubric: topic relevance (50%), originality (25%), appearance and proper referencing (25%)

Grade: 1% bonus (pass/fail)

Perks: All accepted contributions were posted on course website for all to enjoy. Top students presented their work during the final lecture!

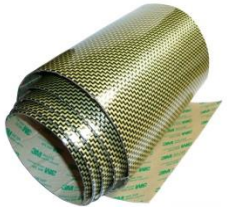
Chemistry Connections Challenge Results

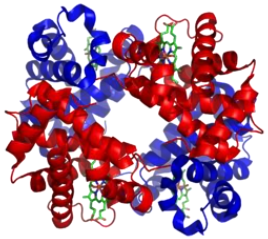
Overall, 324 submissions (~60% of the class) were accepted!

The submissions highlighted course concepts in a wide variety of topics:


natural products


pharmaceuticals


materials


biological systems


chemical warfare


toxicology


entomology


zoology

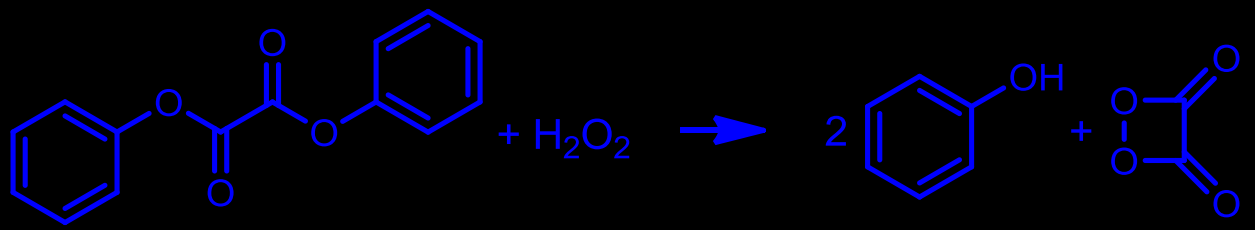

botany

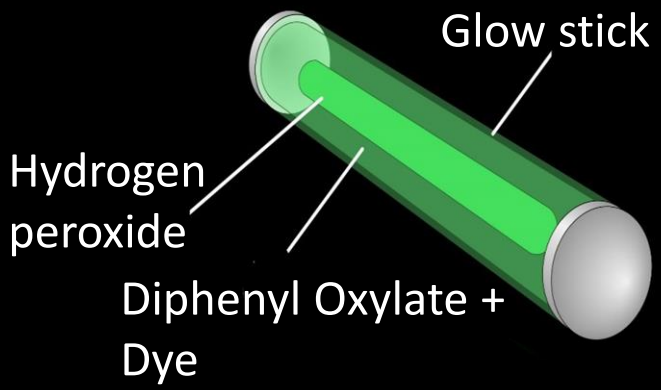
Now, let's see some of the top entries…

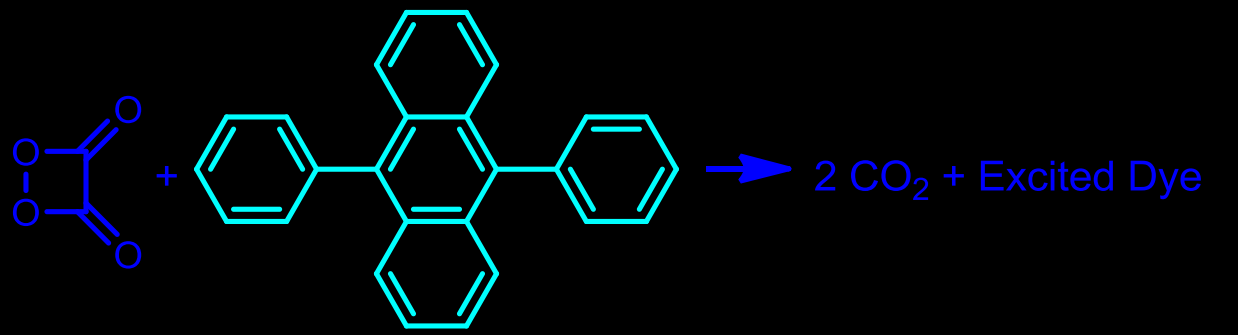
Felicia Hu

How do they glow?

- When glow sticks are bent Hydrogen peroxide is released reacting with Diphenyl Oxylate through an oxidation reaction to produce an unstable product that rapidly decomposes to release Carbon dioxide and energy.
- The energy released is absorbed by the coloured dye (9,10-Diphenylanthracene) and emitted in the form of light.
- Every single coloured glow stick contains a different dye compound that emits the desired visible light.







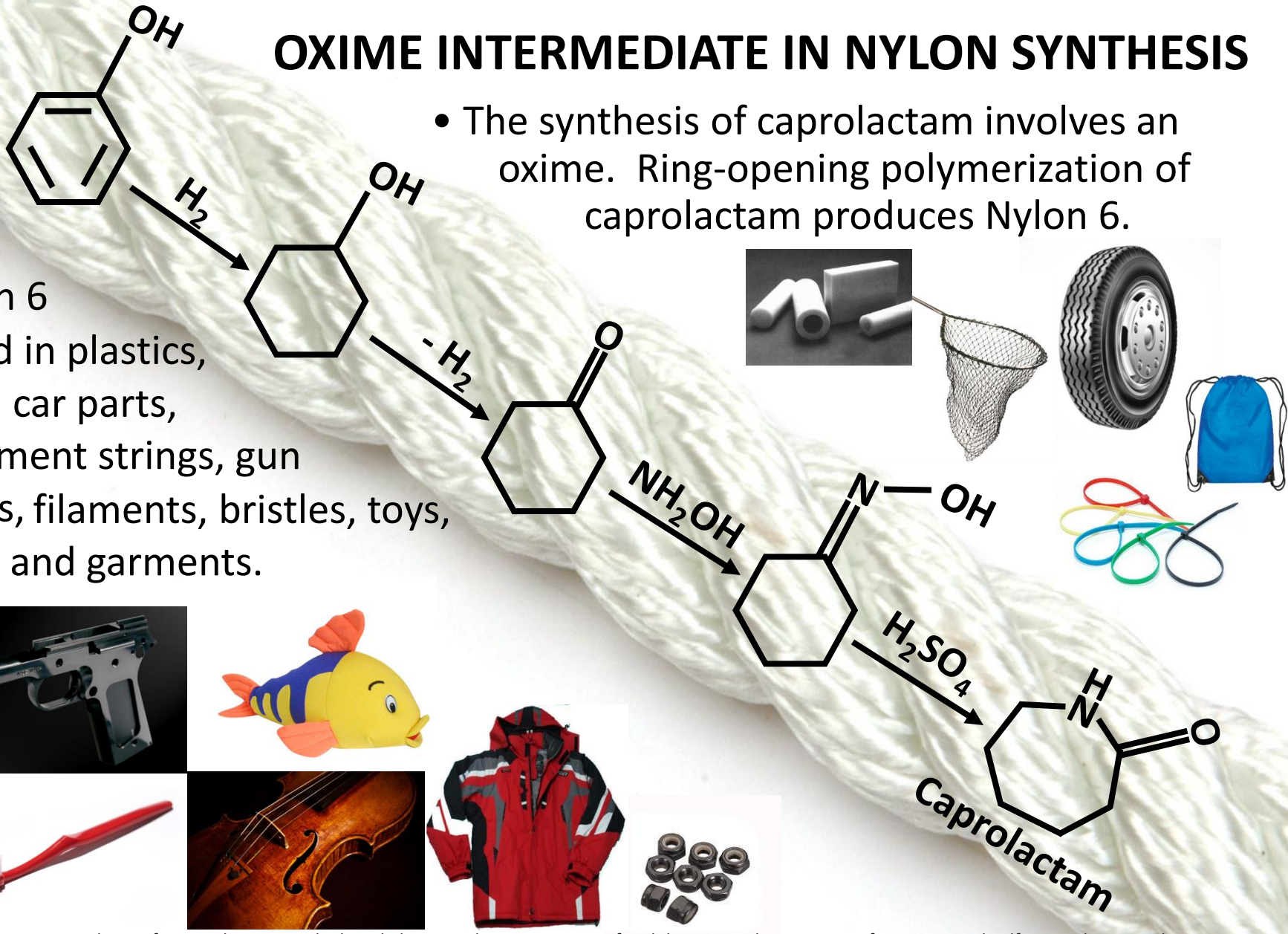
Kuntzleman T, Rohrer K, Schultz E. 2012. The chemistry of light sticks: Demonstrations to illustrate chemical processes. Journal of chemical education. 89(7): 910-916.

Chemistry Connections

OXIME INTERMEDIATE IN NYLON SYNTHESIS

- The synthesis of caprolactam involves an oxime. Ring-opening polymerization of caprolactam produces Nylon 6.

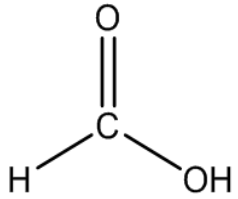
- Nylon 6 is used in plastics, fibers, car parts, instrument strings, gun frames, filaments, bristles, toys, ropes, and garments.



You, K. *et al*. One-step synthesis of ε-caprolactam via the liquid phase catalytic nitrosation of cyclohexane in the presence of concentrated sulfuric acid. *Front. Chem. Sci. Eng.* **6**, 389-394 (2012)

Andrea Chivers

Chemistry Connections



Formic Acid

- Formic acid is the simplest carboxylic acid

- Was the first natural product isolated in insects over 300 years ago
- Used in ants and other insects as a pheromone to signal danger and as a defensive mechanism to deter aerial predators such as birds

- 10-15% of ants' body weight devoted to formic acid which is kept in a poison gland reservoir
- Also commonly found in our atmosphere; scientists estimate that ~50% of the formic acid in our atmosphere is released from ants, matching the amount released from industry

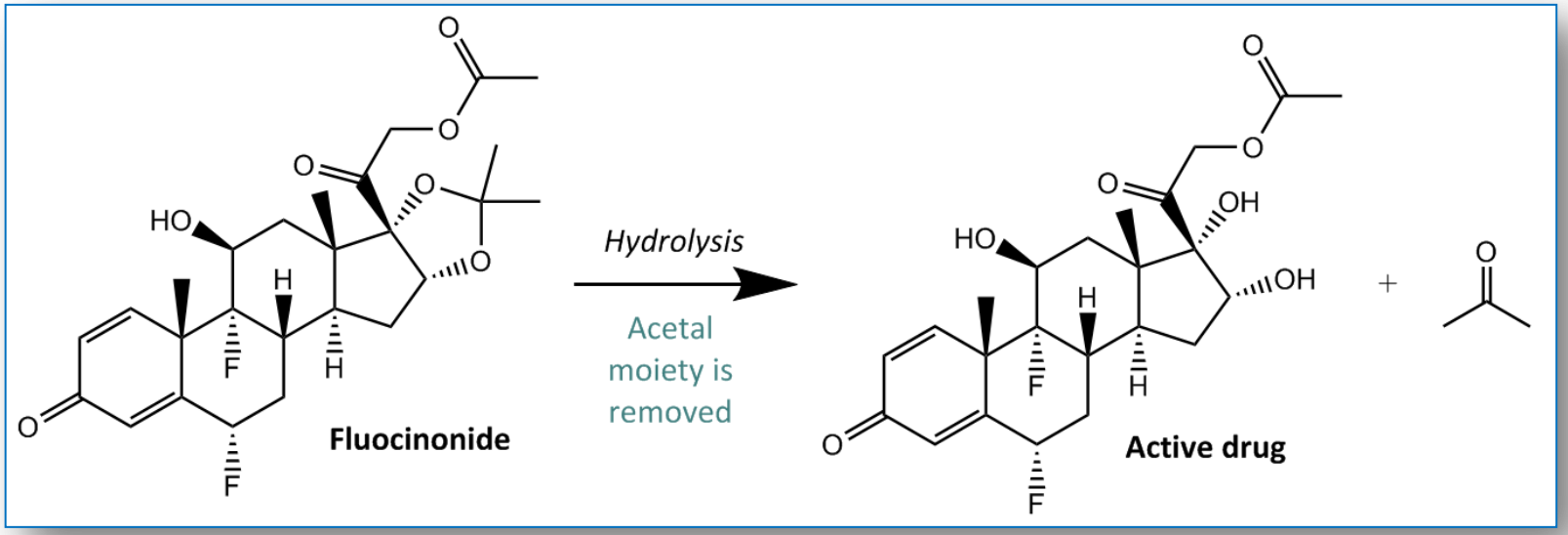
Hefetz A, Blum MS.1978.Biosynthesis and accumulation of formic acid in the poison gland of the carpenter ant Camponotus pennsylvanicus. Science. 201(4354): 454-455.
Monastersky R. Ants and the atmosphere: no picnic. Science News 30 May 1987: 345. *Academic OneFile*. Web. 14 Mar. 2015

Simon Lam

Chemistry Connections

Acetals as Prodrugs

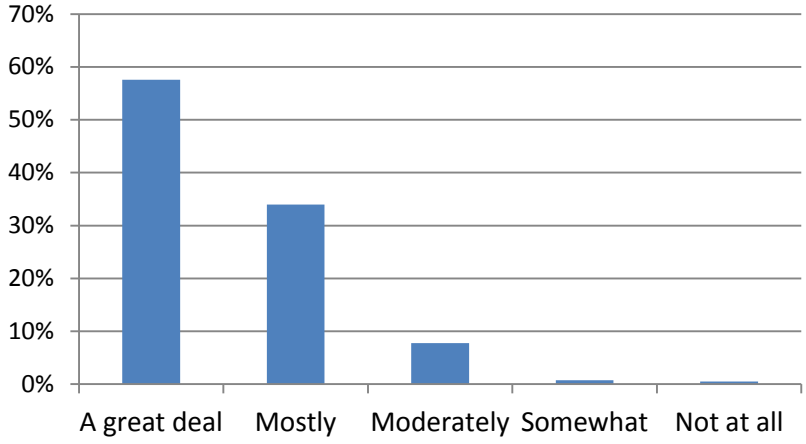
- Skin prevents the absorption of foreign substances
- Prodrugs – pharmacologically inactive compounds that are converted into active compounds by the body – circumvent this problem
- Fluocinonide, a topical cream prodrug for skin conditions, contains an acetal moiety, which allows the drug to penetrate the skin more deeply because it lacks the OH groups that bind to the skin
- In the body, the acetal is hydrolyzed, thereby releasing the active form



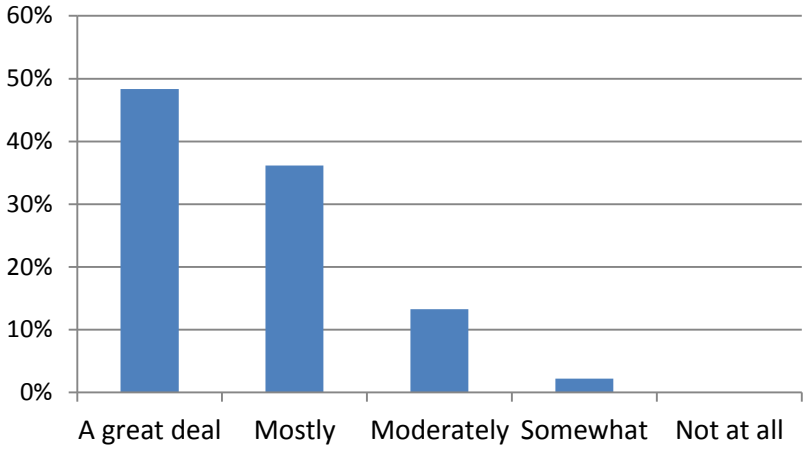
Klein, D. R. (2012). *Organic chemistry*. Hoboken, NJ: John Wiley.

Chemistry Connections Challenge: Student Feedback

The Chemistry Connections Challenge stimulated new ways for me to think about organic chemistry and how it is applied in nature, research, and/or everyday life.



The Chemistry Connections Challenge inspired me to learn more about organic chemistry.



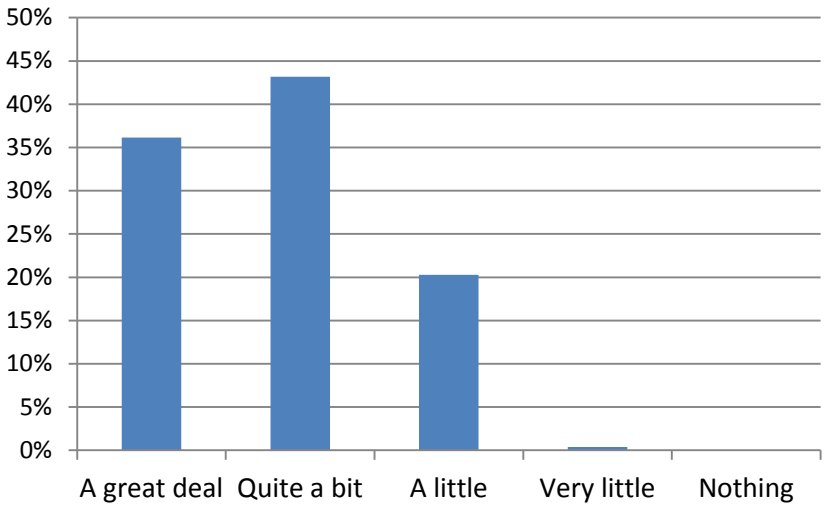
Select Student Comments:

"The assignment allowed me to apply classroom knowledge to real-life. It was really cool finding new reactions and molecules that play important roles in everyday life, and it inspired me to learn more. I have a newfound interest in organic chemistry, so thank you!"

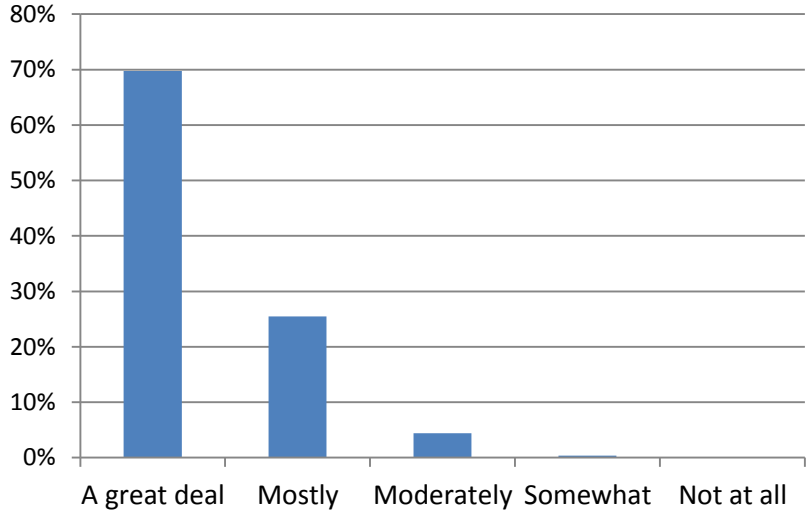
"The Chemistry Connections made me realize how important chemistry is to our society. I didn't realize how much chemistry surrounds us. The overall concept is unique and makes me enthusiastic about the topic! Thank you for sparking my interest in chemistry again! :)"

Chemistry Connections Challenge: Student Feedback

How much do you think you learned while creating your Chemistry Connections slide?



I enjoyed creating my Chemistry Connections slide.



Select Student Comments:

"This was a very fun and creative assignment! It was an excellent opportunity to learn something new related to organic chemistry"

"I like the Chemistry Connection slides in class, but I enjoyed making my own Chemistry Connections slide even more. It encouraged me to think more deeply about how organic chemistry is used industrially."

Chemistry Connections Conclusions

Implementing this assignment helped students to…

- Think beyond the classroom and give relevance to course content by relating topics to the world around them
- Gain an appreciation for the topics learned in class
- Relate course material to their own interests
- Be creative
- Be inspired to learn more and actually enjoy it!

Join me in helping our students to

MAKE CONNECTIONS

in your courses!

Please join into small groups and brainstorm ideas for your own "*Connections Slides*" that you could implement in one of your courses!