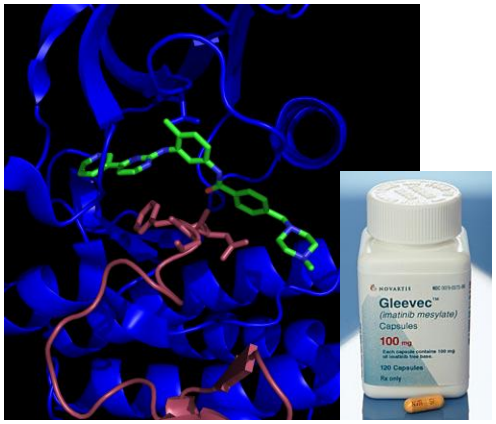
General Chemistry Innovations in Five-Minute Increments

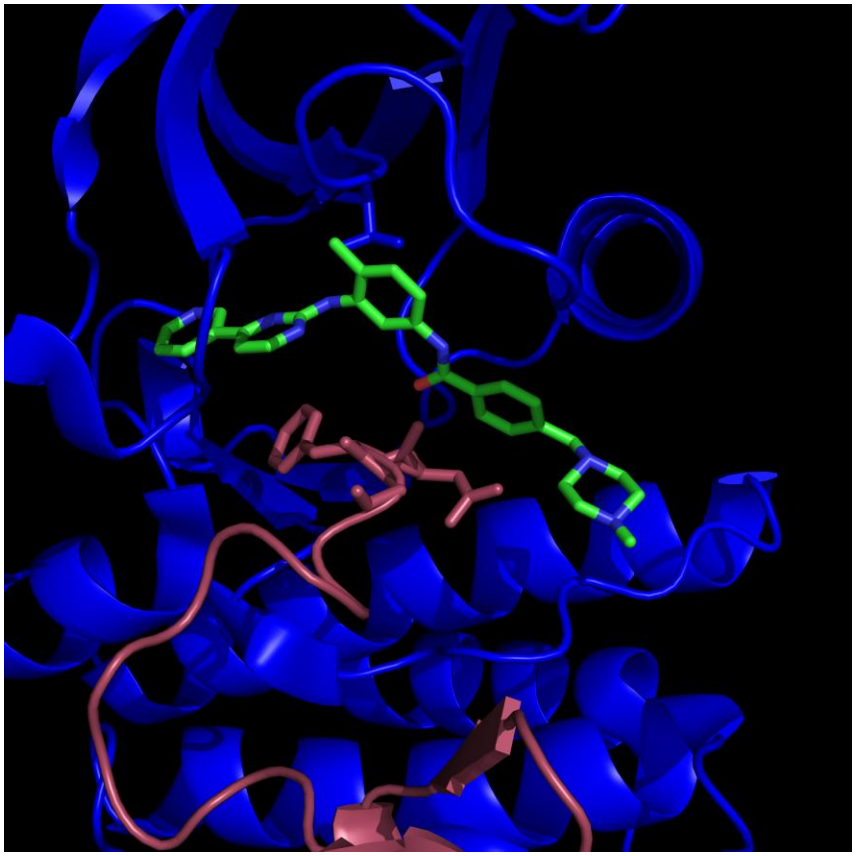


Beth Vogel Taylor
Cathy Drennan

Bringing the “Why” and “Who” into General Chemistry

Observations and Concerns

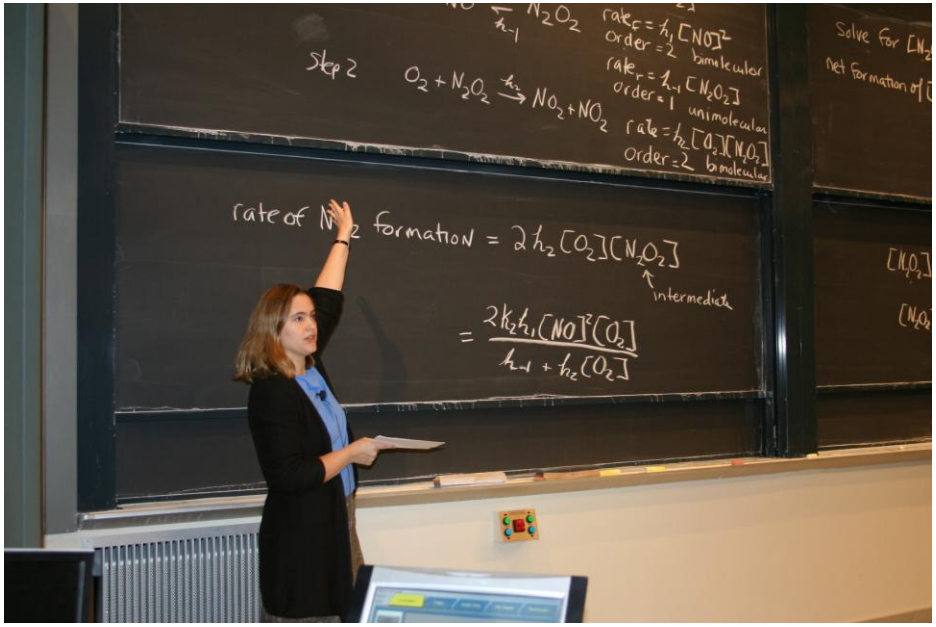
- Undergraduates are interested in biology/medicine, but they don't see the connection to chemistry.



Bringing the “Why” and “Who” into General Chemistry

Observations and Concerns

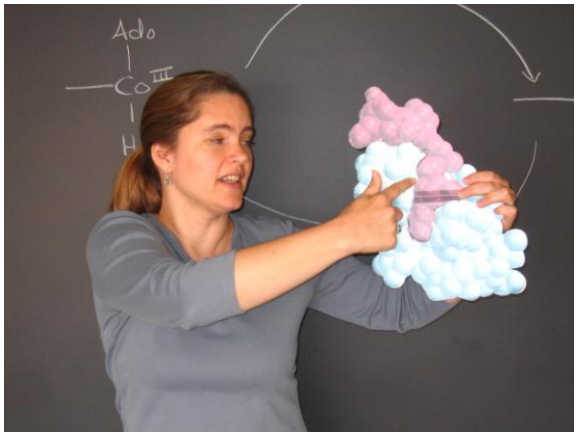
- Undergraduates are interested in biology/medicine, but they don't see the connection to chemistry.
- There is little room in most general chemistry curricula to add new units and few schools have the resources for creating a new interdisciplinary course.

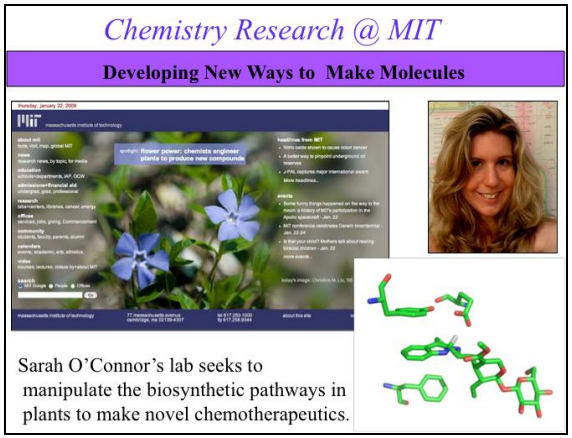


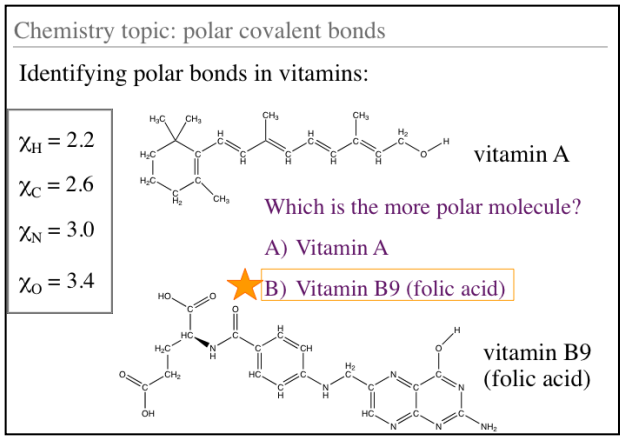
Can small changes lead to meaningful improvements?

Can small changes lead to meaningful improvements?

Vehicle: Quick (2 to 5 minute) in-class examples relating each chemistry topic covered to applications in biology, medicine, and MIT research.







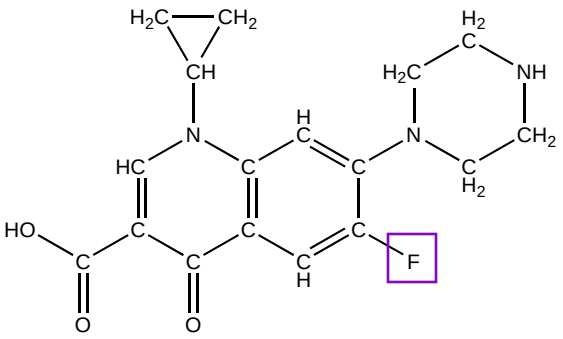
Vehicle: A series of short videos illustrating the "Faces of Chemistry at MIT".

What do our lecture examples look like?

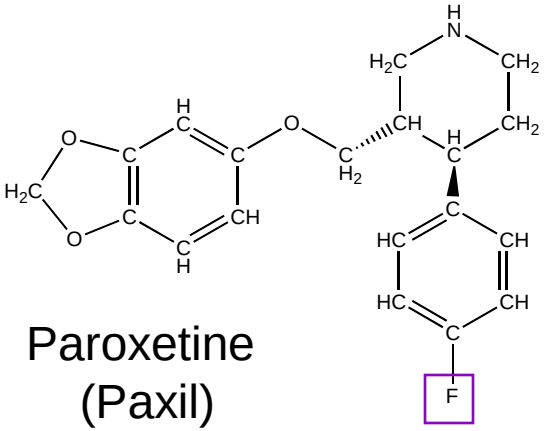
What do our lecture examples look like?

Chemistry topic: oxidation and reduction

Carbon-fluorine bonds in drugs



Ciprofloxacin (Cipro)
broad-spectrum antibiotic



Paroxetine
(Paxil)
antidepresent

Replacing a C-H bond with a C-F bond can make a drug candidate more electron poor.

What do our lecture examples look like?

Chemistry topic: oxidation and reduction

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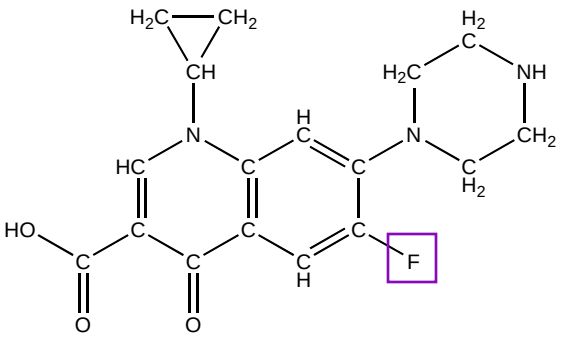

Ciprofloxacin (Cipro)
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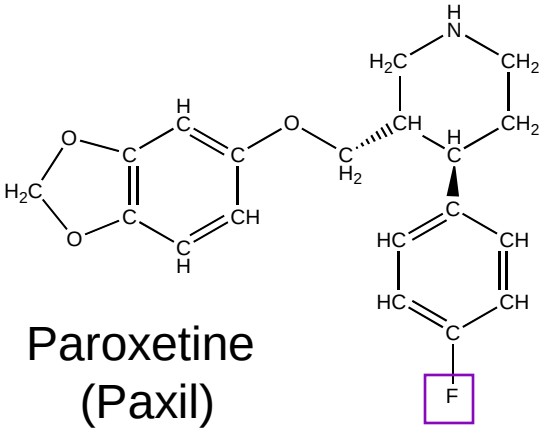


Paroxetine
(Paxil)
antidepresent

An electron-poor drug is _____.

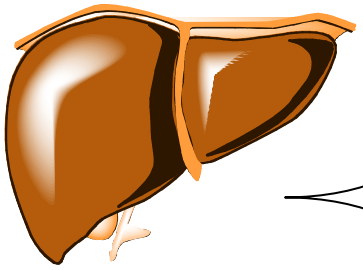
A) harder to oxidize

B) easier to oxidize

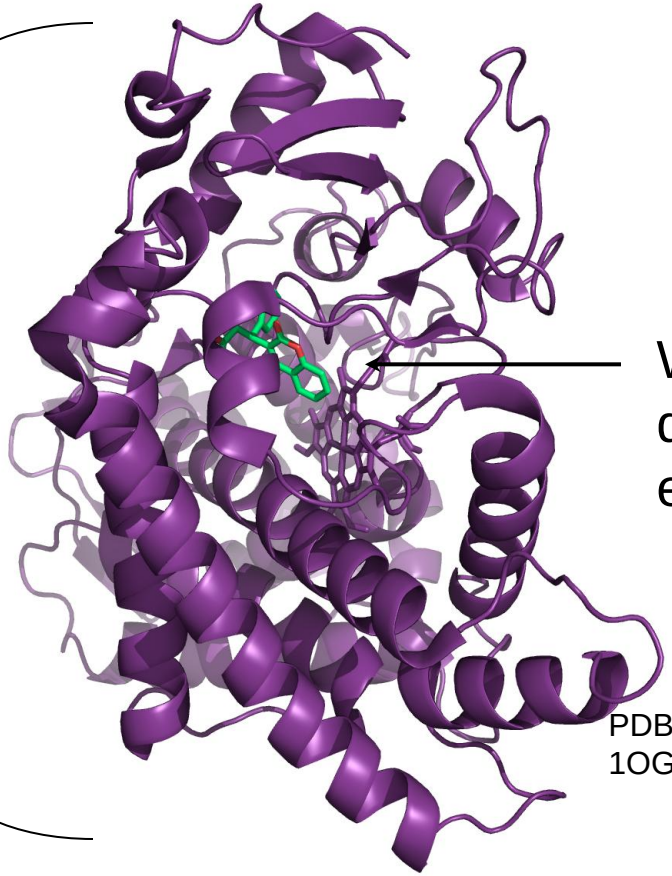
C) neither harder nor easier to oxidize than an electron-rich version of the drug

What do our lecture examples look like?

Cyp enzymes in the liver oxidize small molecules (such as drugs!) for excretion from the body



liver



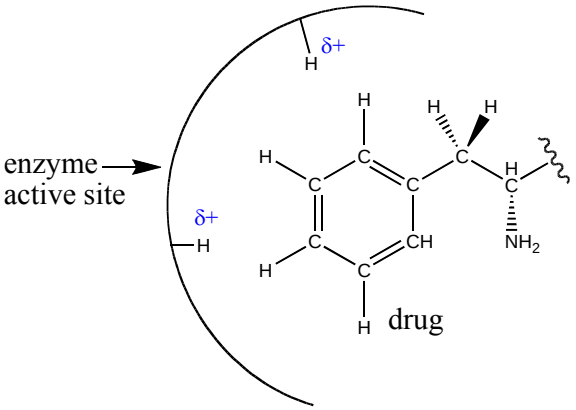
Warfarin (an anti-coagulant drug) bound to a Cyp enzyme

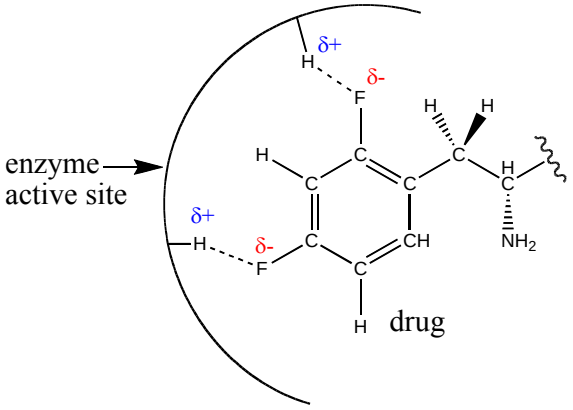
PDB file: 1OG5

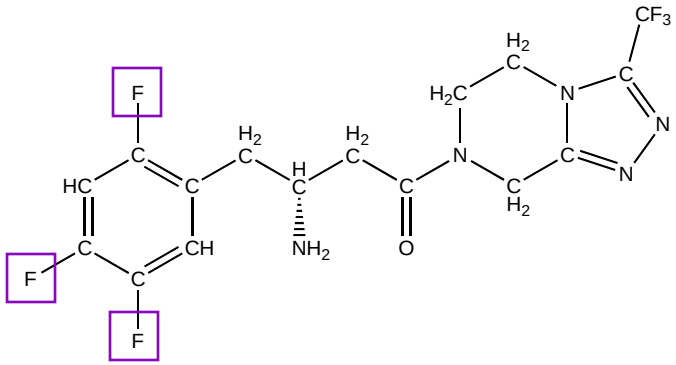
Fluorination can increase a drug's metabolic stability.

Biology-related examples create links between topics

As hydrogen-bond acceptors, F atoms can also lead to tighter drug binding in the active site of a target enzyme.







Sitagliptin (Januvia)
anti-diabetic

FDA approved in 2006

Assessing the impact of biology-related examples

Assessing the impact of biology-related examples

Teaching and Learning Laboratory at MIT

Rudy Mitchell, Ed.D.
Associate Director for Assessment and Evaluation

7 point rating scale

1.....4.....7

poor/ strongly disagree	neutral	excellent/ strongly agree

- ✓ 15-minute online retrospective surveys
- ✓ MIT standard subject evaluations

(magic number of $15 for ~80% student response rate)

Assessing the impact of biology-related examples

Following the course, freshman reported an interest in chemistry and a recognition of the relationship between chemistry and biology.

	Mean (SD)	N
S2A. I find chemistry interesting.	5.75 (1.27)	343
S2B. I would like to learn more chemistry.	5.52 (1.54)	341
S2C. In order to understand biology well, one must know some chemistry.	6.13 (0.96)	343
S2D. Chemistry is relevant to the field of biology.	6.34 (0.74)	343
S2E. Chemistry is relevant to medicine and other health care professions.	6.59 (0.63)	342
S2F. Knowing chemistry is of minimal value unless a student intends to major in chemistry or a related discipline.	2.57 (1.36)	342

Students credited the course for contributing to their positive views and attitudes.

ie. 86% of the class reported that lecture examples helped them see connections between biology and chemistry.

ACS Chem. Biol. (2009)

Assessing the impact of biology-related examples

MIT subject evaluations enabled direct comparison with years prior to course innovations.

2006: no bio-related examples (N=135)

2007: bio-related examples throughout half of the course (N=198)

2008: biology-related examples throughout the course (N=160)

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2007: bio-related examples throughout half of the course (N=198)

2008: biology-related examples throughout the course (N=160)

1.....4.....7

poor/ strongly disagree — neutral — excellent/ strongly agree

*indicates statistical significance

Assessing the impact on specific target groups

Assessing the impact on specific target groups

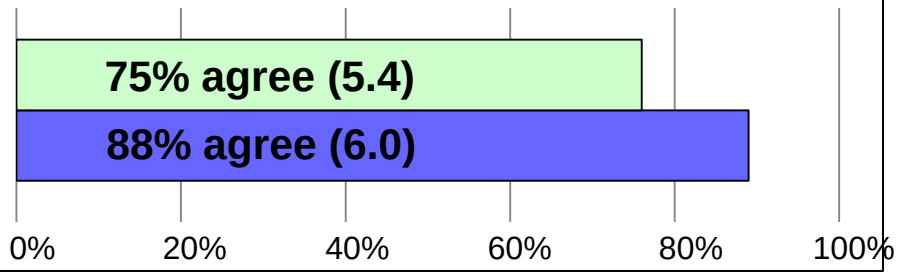
Pre-medical students (28% of the class)

General chemistry ***without*** biology-related examples (N = 62)

General chemistry ***with*** biology-related examples (N = 132)

As a result of this course…

I see the relevance of chemical principles to biology, medicine, and health care.*



"Subject content was interesting and I LOVED the connections to biology."

"…made me love chemistry"

* statistically significant difference between cohorts

1.....4.....7

strongly disagree — neutral — strongly agree

Assessing the impact on specific target groups

Pre-medical students (28% of the class)

General chemistry ***without*** biology-related examples (N = 62)

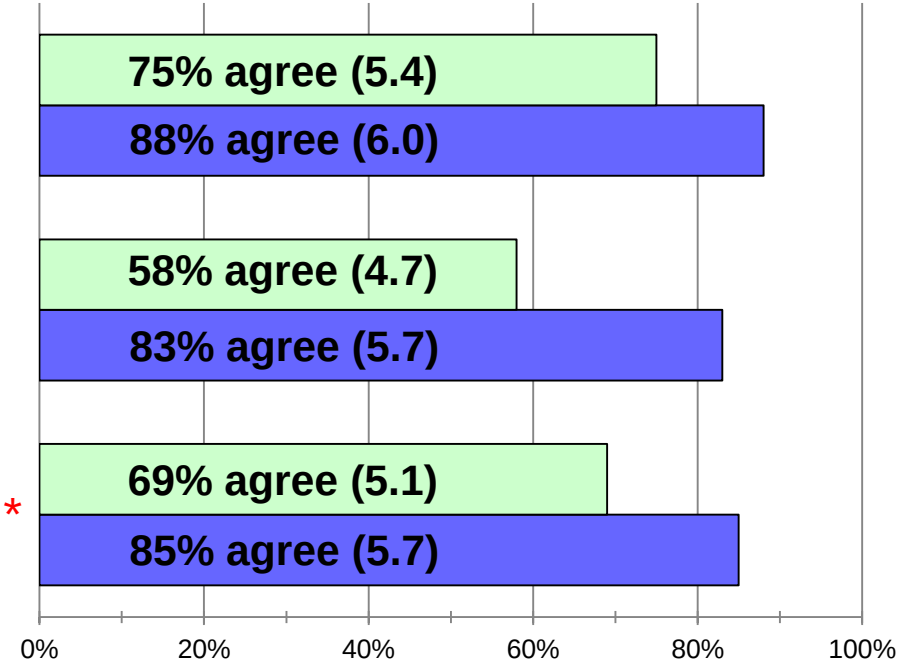
General chemistry ***with*** biology-related examples (N = 132)

As a result of this course…

I see the relevance of chemical principles to biology, medicine, and health care.*

my interest in chemistry increased.*

I am interested in learning more chemistry.*



* statistically significant difference between cohorts

1.....4.....7

strongly disagree — neutral — strongly agree

Assessing the impact on specific target groups

Biology-related majors (59% of the class)

General chemistry ***without*** biology-related examples (N = 99)

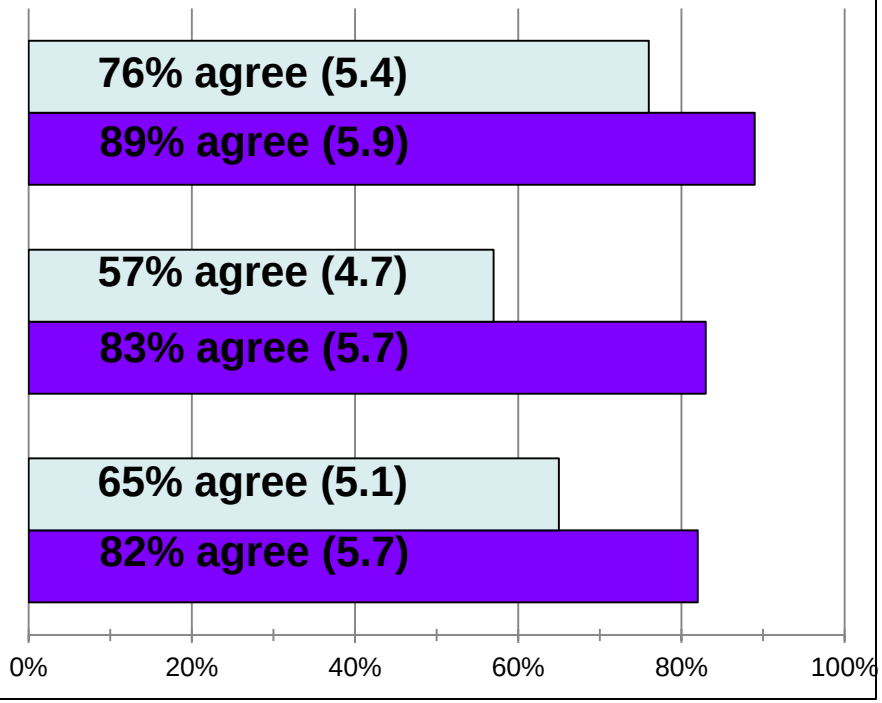
General chemistry ***with*** biology-related examples (N = 308)

As a result of this course…

I see the relevance of chemical principles to biology, medicine, and health care.*

my interest in chemistry increased.*

I am interested in learning more chemistry.*



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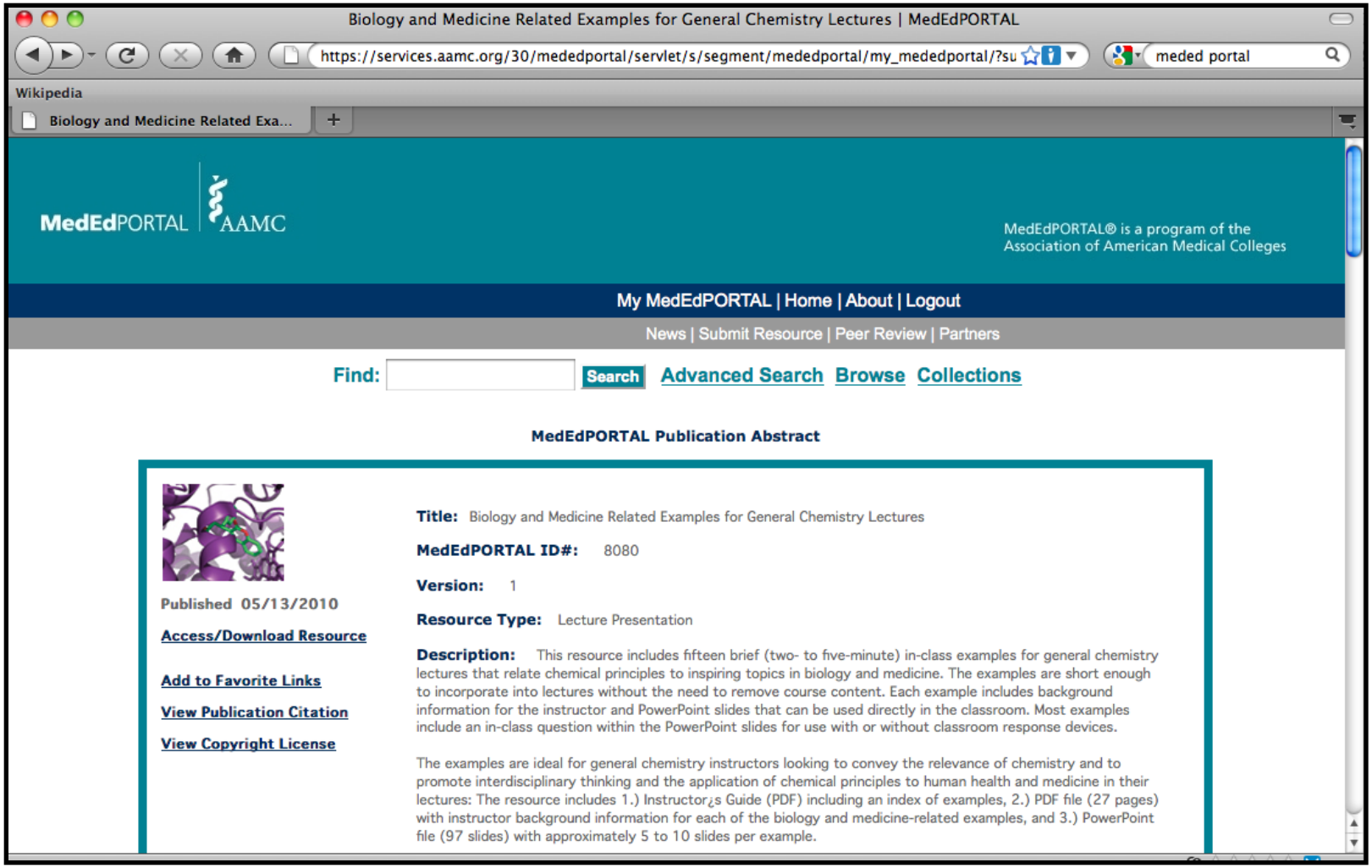
1.....4.....7

strongly disagree — neutral — strongly agree

Dissemination of resources: reaching teachers

MedED PORTAL

Our medicine-related examples for general chemistry were selected to pilot a site with teaching resources for pre-med courses.



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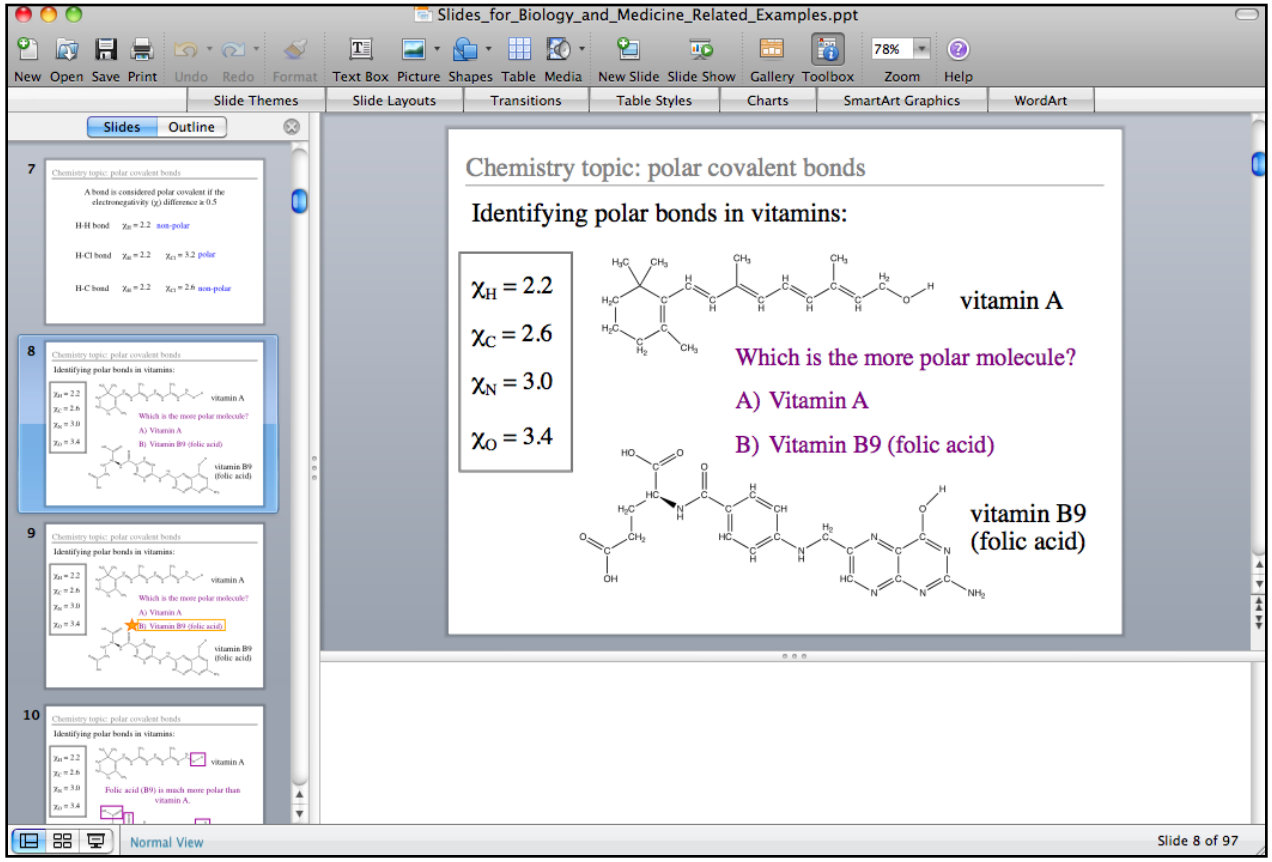


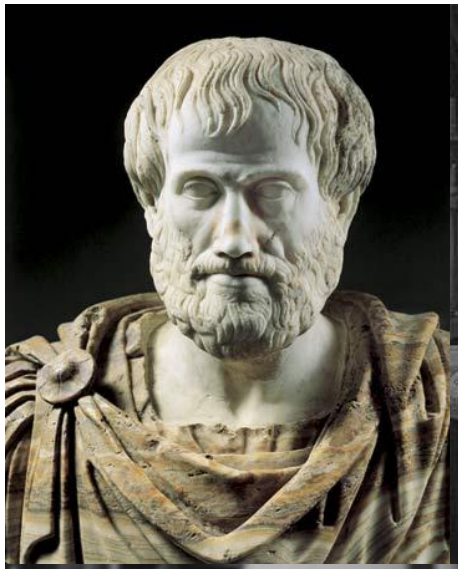
For each example:

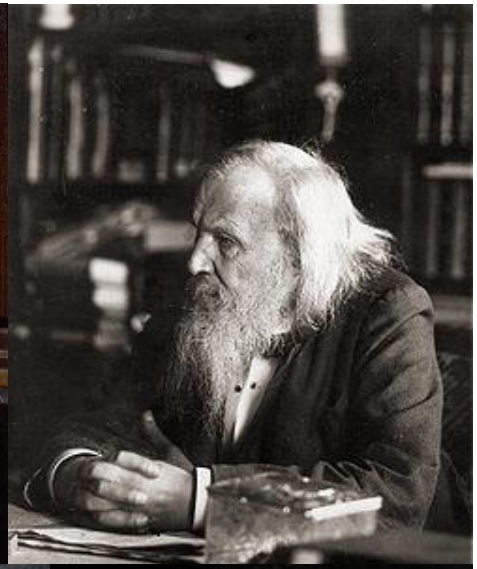
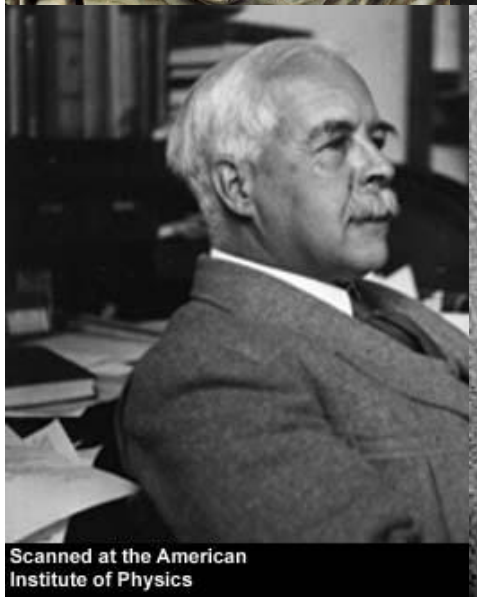
- 3 to 5 slides
- one concept-based chemistry question
- background info. for the instructor

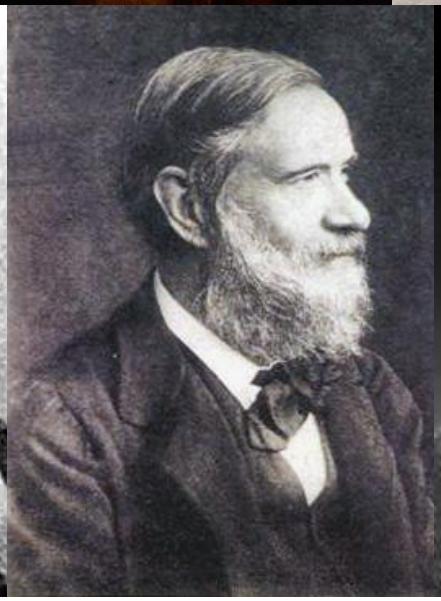
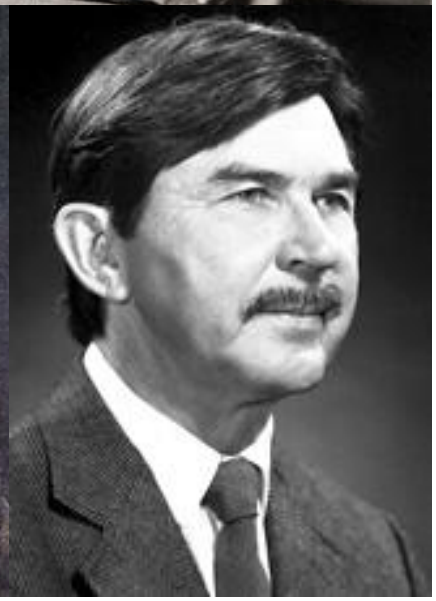
Can small changes lead to meaningful improvements?

Vehicle: A series of short videos illustrating the “Faces of Chemistry at MIT”.

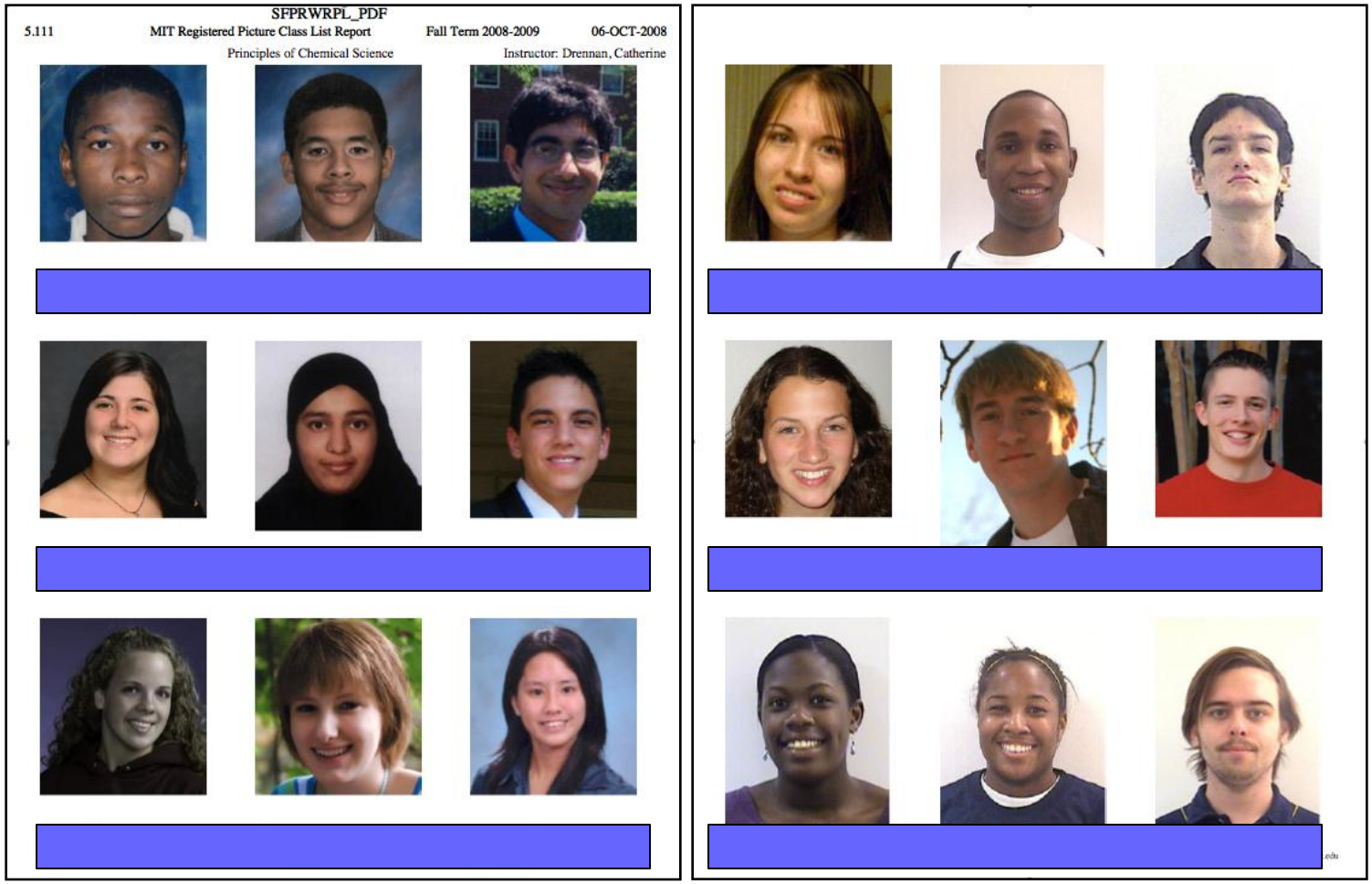
The “Who” of Chemistry (pictures from 5.111 “lecture 1”)



The “Who” of Chemistry (our students)



33%* of course 5.111 (general chemistry) freshmen identify as underrepresented minority students.

*averaged over Fall 2007-2010 and Spring 2010-2011 semesters (N = 597)

How do we increase the impact on URM students / women?

Inspiration from discussions and evaluation comments:

This is one of the very few science/engineering classes that are taught by female professors. I've been here at MIT for 4 years, and this class is the 2nd class I've had with female professors. I think it's super important to give a sense that women can do science and engineering too.

Research Videos showing the Faces of Chemistry at MIT

The *Why* and the *Who* of Chemistry

Do people actually use the stuff they learn in freshman chemistry?

What do real chemists look like (apart from the dead white men in textbooks)?

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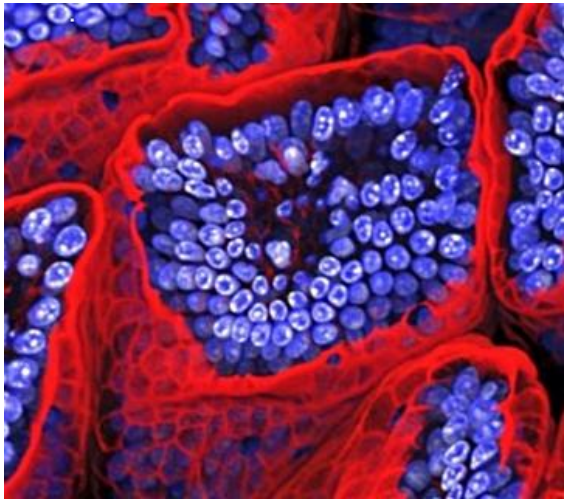
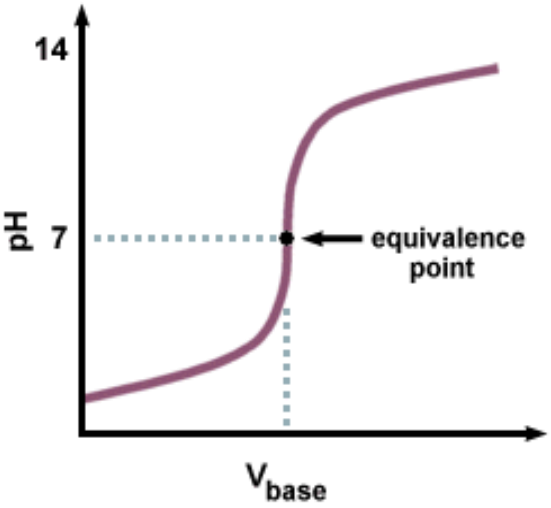
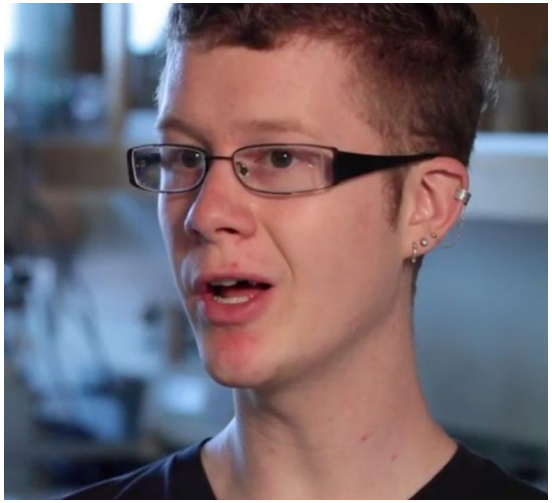




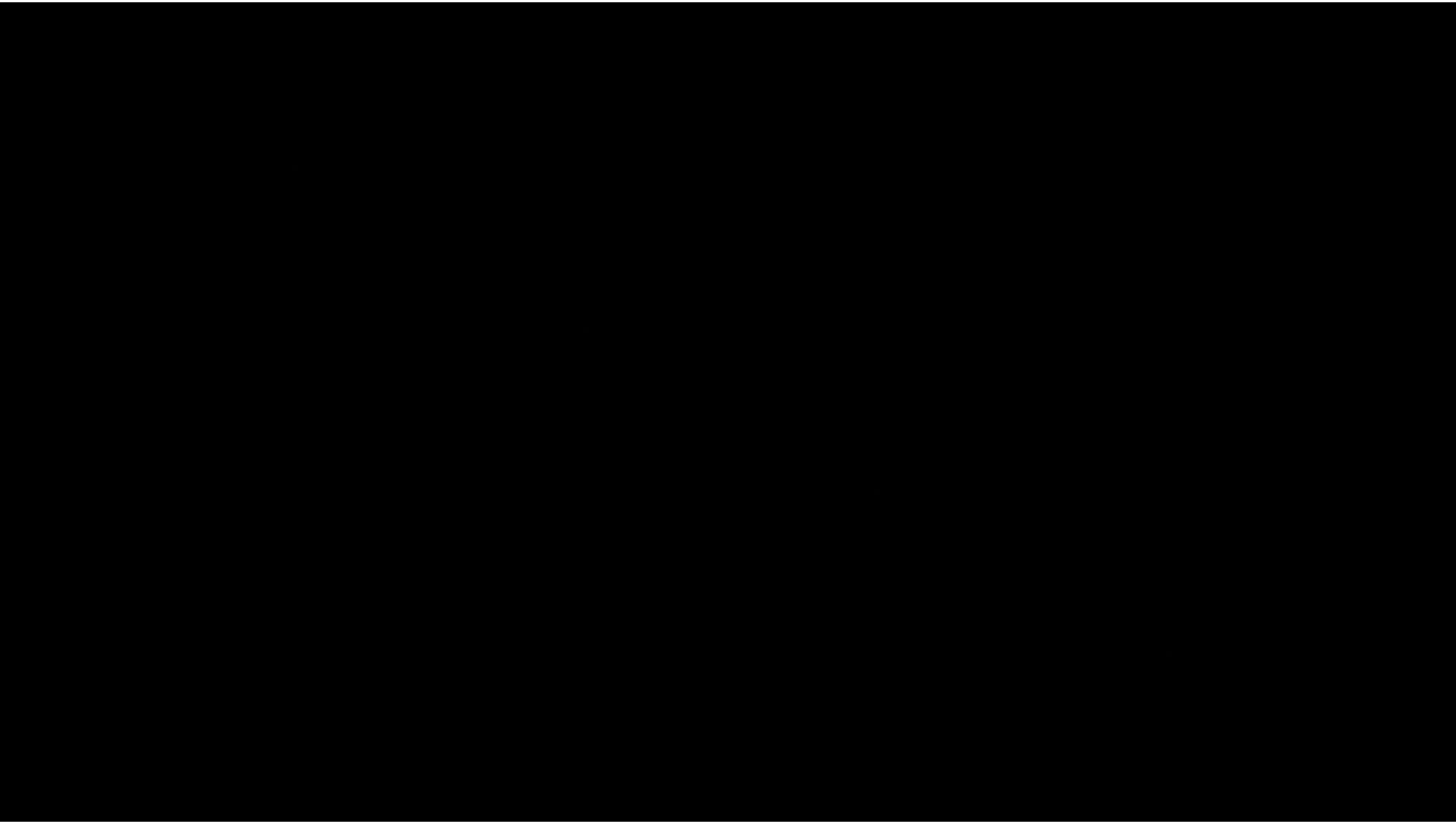


Application:
imaging diseased cells

General chemistry topic:
pH and pKa

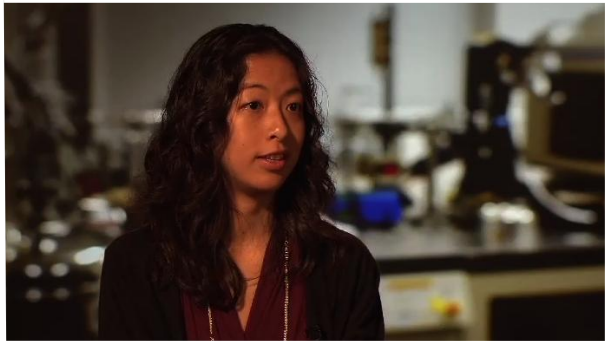
MIT Researcher:
undergraduate
Sam Thompson

Samuel Thompson: MIT undergraduate in the Ting lab














Assessing impact: Faces of Chemistry videos

Assessing impact: Faces of Chemistry videos

From Spring 2011 Retrospective Survey (no videos yet!)

As a result of this class,	mean	% agree
I have been exposed to examples of chemists from different ethnic groups.	4.2	43%
I have been exposed to examples of women who are chemists (in addition to my professors and Tas)	5.4	81%
I encountered examples of chemists with whom I could identify because of their gender/ethnicity/background.	4.4	42%

1.....4.....7

poor/ strongly disagree

neutral

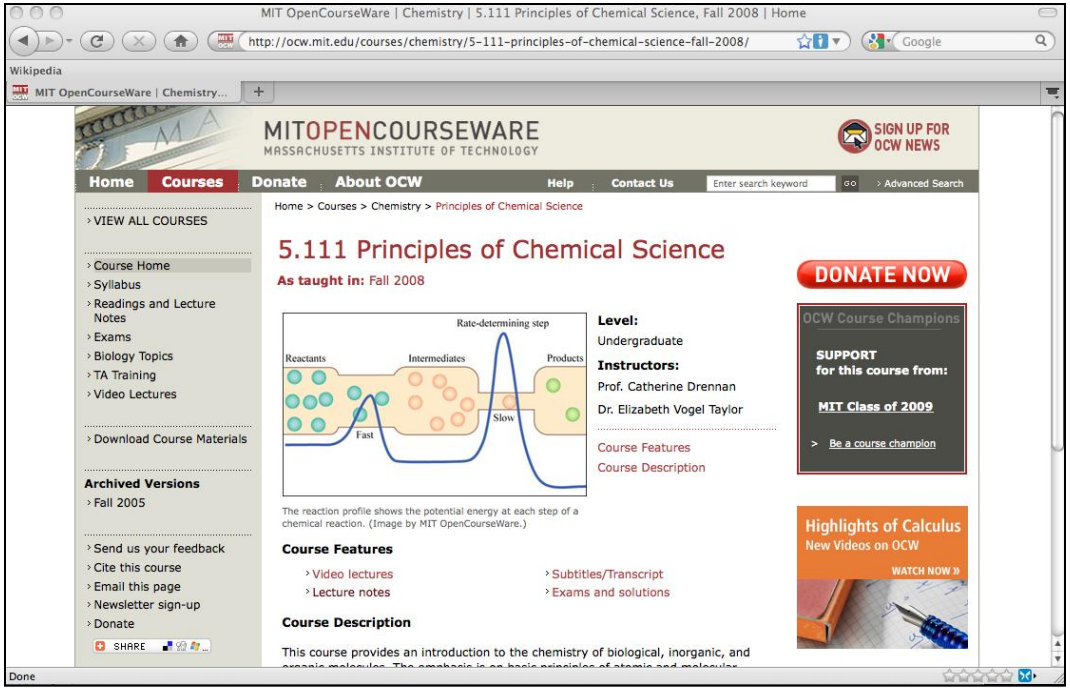
excellent/ strongly agree

Dissemination of resources: reaching teachers

MIT OpenCourseWare

Available materials: lecture notes, videos, transcripts, exams, etc.

Bio. examples highlighted, but not formatted for direct use by teachers



5.111 is the 13 most-viewed course on OCW (out of 2,000 total)

- over 40,000 distinct page views per month
- over 6,000 downloads per month

Dissemination of resources: reaching teachers

OCW Secondary Education

Goal: provide TEACHING resources

(not just AP study resources for students)

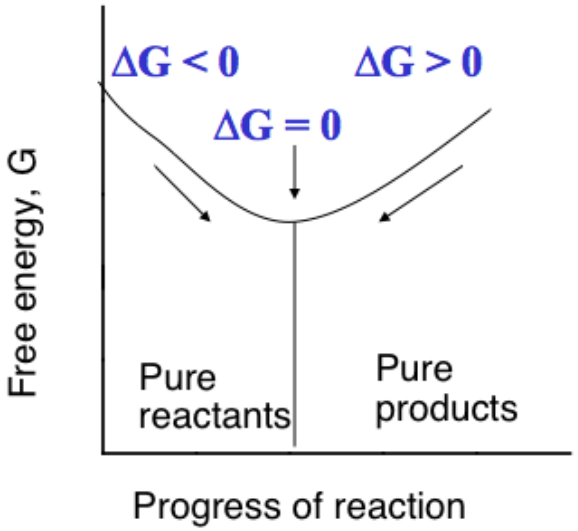
Research Videos showing the Faces of Chemistry at MIT

The *Why* and the *Who* of Chemistry

Do people actually use the stuff they learn in freshman chemistry?

What do real chemists look like (apart from the dead white men in textbooks)?

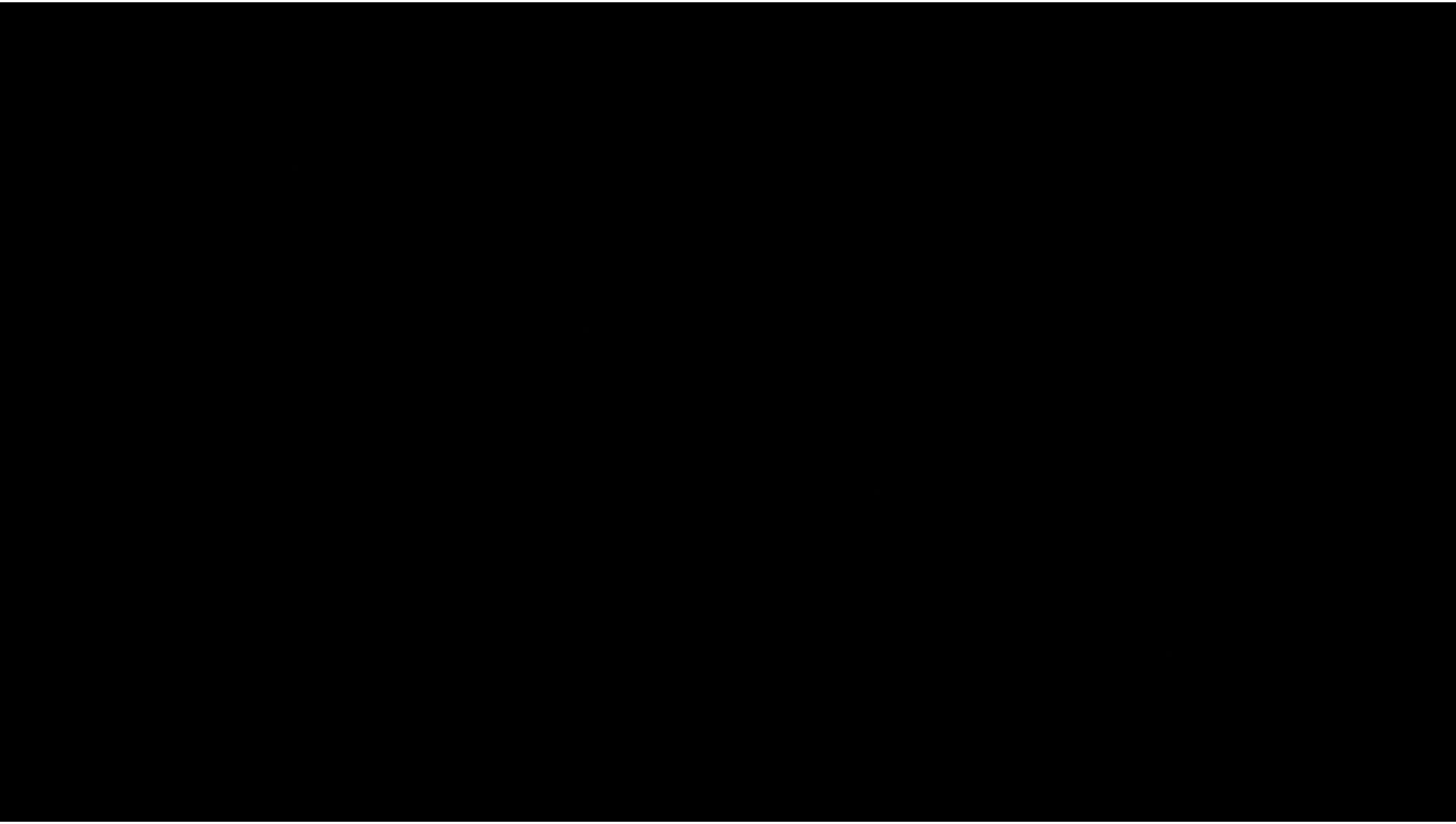
Engineering microbes to remove greenhouse gasses



General chemistry topic: Chemical Equilibrium

MIT Researcher: Hector Hernandez

Hector Hernandez: MIT Postdoctoral Associate



Who is involved

HHMI
HOWARD HUGHES MEDICAL INSTITUTE

Massachusetts Institute of Technology
class of 2009

Lourdes Aleman
Nazomi Ando
Sarah Bowman
John Essigman
Wes Glenn
Hector Hernandez
Meredith Knight
Jingnan Lu
Ben Ofori-Okai
Stefanie Sydlik
Sam Thompson
Darcy Wanger

Cathy Drennnan

Rudy Mitchell

George Zaidan

Mary O'Reilly