Eurovariety 2013: "Smarter teaching – better learning", 5 July 2013

TEACHING CHEMISTRY IN THE CONTEXT OF A CROSS-DISCIPLINARY RESEARCH SEMINAR

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Abstract

We report on the design, implementation and assessment of the research seminar offered as part of the NSF-PRISM supported "Mathematics and Life Sciences" program at MU. The seminar format aims for 25-minute research talks followed by 25 minutes of defense, discussion and extrapolation. The emphasis on equal time between presentation and scientific discussion is a stratagem of this course to stimulate open and frank discussion and cross- and interdisciplinary brainstorming, exchange and education, and student performance is assessed in this spirit. The seminar grade is affected by the student's attendance, the assessment of the student's research presentation (rubric-based peer review of science content and presentation skills), the assessment of the student's peer reviewer performance (meaningful, balanced, written constructive criticism), and the assessment of the student's discussant performance (attention and comprehension; seeking and providing clarification; content of mini-paper; contribution to discussion). The grading scheme reflects a shift from the traditional assessment of the speaker to an assessment of members of the learning community. The presentation will highlight how such a class is socializing students for research.

Background

"Although mathematics has long been intertwined with the biological sciences, an explosive synergy seems poised to enrich and extend both fields greatly in the coming decades."

Joel E. Cohen, Abby Rockefeller Mauzé Professor of Populations at Rockefeller University and Professor of Populations at the Earth Institute of Columbia University. Cohen, J. E. (2004) Mathematics Is Biology's Next Microscope, Only Better; Biology Is Mathematics' Next Physics, Only Better. PLoS Biol 2(12): e439. doi:10.1371/journal.pbio.0020439

"Recent research using tools from the biological, mathematical, and computer sciences has led to dramatic improvement in our understanding of biology, medicine, and the environment. … As these new cross-disciplinary fields continue to develop new knowledge, techniques, and processes, they create even more opportunities for new biological research."

Carol Brewer, Professor of Biological Sciences and Associate Dean of the College of Forestry and Conservation at the University of Montana; and Daniel Maki, Professor Emeritus at Indiana University and Director of the National Science Foundation Math and Science Partnership Program. Brewer, C. A.; Maki, D. Building the Renaissance Team. In Math & Bio 2010 – Linking Undergraduate Disciplines, Steen, L. A. (Ed.). The Mathematical Association of America: Washington, D.C., 2005, p. 45-50.

Background

Science AAAS

SPECIAL SECTION

MATHEMATICS IN BIOLOGY

VIEWPOINT

Introductory Science and Mathematics Education for 21st-Century Biologists

William Bialek[1,3] and David Botstein[2,3*]

Galileo wrote that "the book of nature is written in the language of mathematics"; his quantitative approach to understanding the natural world arguably marks the beginning of modern science. Nearly 400 years later, the fragmented teaching of science in our universities still leaves biology outside the quantitative and mathematical culture that has come to define the physical sciences and engineering. This strikes us as particularly inopportune at a time when opportunities for quantitative thinking about biological systems are exploding. We propose that a way out of this dilemma is a unified introductory science curriculum that fully incorporates mathematics and quantitative thinking.

Science **2004**, *303*, *788-790*.

Background

bioscience
education
Publishing original articles on tertiary-level bioscience education

Math + Science = Success

Llamas *et al.* analyzed 10 years of test results from undergraduate students enrolled in a plant physiology course in Spain. Only a basic level of mathematics knowledge appropriate to the students' background was required for answering the test questions. Questions requiring mathematical skills were defined as those that required calculations, interpretation of graphs, or analysis of a numeric table. Success on these questions was found to be 16% lower than success on corresponding nonmathematical questions. Moreover, mathematics-based questions were more often left blank, which suggests that the students themselves may doubt their ability to answer the question. Interestingly, success on mathematics questions ran in parallel with success in the course. These results highlight the need to integrate mathematical literacy into undergraduate biology courses to help students apply previously acquired skills to enhance their interest, and success, in biology. — MM

Abstracted in *Science* **2012**, *337*, 504. Llamas, A., Vila, F., Sanz, A. *Mathematical Skills in Undergraduate Students. A Ten-year Survey of a Plant Physiology Course. Bioscience Education* **2012**, *19* available at http://www.bioscience.heacademy.ac.uk/journal/vol19/beej-19-5.aspx

Background

S. James Gates Jr. is the Toll Physics Professor and director of the Center for String & Particle Theory at the University of Maryland, College Park, MD. E-mail: gatess@umd.edu.

EDITORIAL: **Engage to Excel**

"Why do undergraduate students leave STEM during the first 2 years? Studies indicate three primary reasons: uninspiring introductory courses, difficulty with the required math, and an academic culture in STEM fields that is often unwelcoming. These problems can be especially severe for members of groups underrepresented in STEM fields, including women and minorities, who today constitute about 70% of college students but earn only 45% of STEM degrees."

S. James Gates Jr. and Chad Mirkin *Science* **2012**, *335*, 1545.

Chad Mirkin is the Rathmann Professor of Chemistry and director of the International Institute for Nanotechnology at Northwestern University, Evanston, IL. E-mail: chadnano@northwestern.edu.

Background

math + science = success™

Our nation's future just might depend on two simple words: math and science.

Fortunately, with the right encouragement, most students can excel in these subjects. On this website, you can find math and science resources for students, parents, and educators. If there isn't already a math + science = success initiative in your area, contact us to learn how to start one.

http://www.mathsciencesuccess.org/

The NSF-PRISM Program

The goal of the program in Proactive Recruitment in Introductory Science and Mathematics is to strengthen the nation's scientific competitiveness by increasing the numbers of well-prepared, successful U.S. undergraduate majors and minors in science and mathematics. The program will fund innovative, potentially transformational partnerships between the mathematical sciences and other science or engineering disciplines that widen the cross section of the mathematical sciences to which freshman and sophomore students are exposed and that provide these students increased opportunities for research experiences involving the mathematical sciences.

Types of Interdisciplinary Scholarship

Type of Scholarship	Teaching	Research
Informed Disciplinary	Disciplinary Courses informed by other discipline(s)	Disciplinary questions requiring outreach to other discipline(s)
Synthetic Interdisciplinary	Courses that link disciplines	Questions that link disciplines
Transdisciplinarity	Courses that cross disciplines	Questions that cross disciplines
Conceptual Interdisciplinary	Courses without a compelling disciplinary basis	Questions without a compelling disciplinary basis

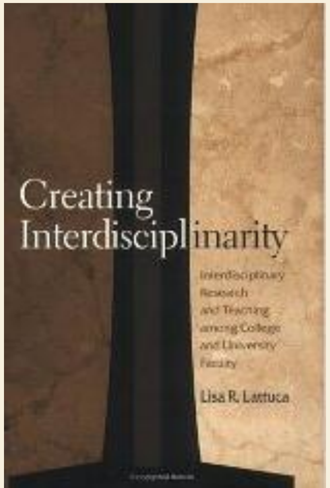

Table 4.1, p. 81, in Lisa Lattuca, *Creating Interdisciplinarity: Interdisciplinary Research and Teaching among College and University Faculty.* Vanderbilt University Press, 2001.

Types of Interdisciplinary Scholarship

Typology	Previous Categorizations
Informed Disciplinary	Instrumental interdisciplinarity Pseudointerdisciplinarity Cross-disciplinarity Partial interdisciplinarity
Synthetic Interdisciplinary	Instrumental or cross-disciplinarity that is motivated by an interdisciplinary question Multidisciplinarity Partial interdisciplinarity Conceptual Interdisciplinary
Transdisciplinarity	Transdisciplinarity Cross-disciplinarity
Conceptual Interdisciplinary	(True) interdisciplinarity Critical interdisciplinarity Full interdisciplinarity

Table 4.2, p. 114, in Lisa Lattuca, *Creating Interdisciplinarity: Interdisciplinary Research and Teaching among College and University Faculty*. Vanderbilt University Press, 2001.

PRISM Principal Investigators @ MU

Dix Pettey
Mathematics

George Smith
Biolog. Sciences

Frank Schmidt
Biochemistry

Rainer Glaser
Chemistry

Jennifer Hart
ELPA

COLUMBIA DAILY TRIBUNE
COLUMBIA, MISSOURI

Grant aims to integrate disciplines

MU gets $2 million to give to math, science students.

By JANESE HEAVIN

Friday, August 14, 2009

Hoping to close a disconnect between math and life sciences, the University of Missouri will start offering scholarships to a select group of freshmen interested in those fields.

A $2 million grant from the National Science Foundation will allow the university to provide scholarships and stipends to 20 incoming freshmen every fall for the next five years. The Mathematics in Life Sciences Scholars will be placed in a Freshmen Interest Group that will take a one-credit seminar and conduct summer research projects. In addition to needs-based scholarships, scholars also will receive $3,500 stipends for their summer work.

"The idea is to bring these two cultures together," said Frank Schmidt, who helped pursue the grant. "Most people who do life sciences don't realize how well mathematics fits in with what they're doing."

Dix Pettey, a math professor and principal investigator for the grant, said MU originally had hoped to start the program next fall, but the grant required it to be implemented this year. Nearly 500 incoming freshmen who fit the bill were invited to apply for the scholars program. They will be selected once the application period closes this weekend.

MLS Program @ MU: Goals

The Two-part goal:

1) recruit mathematically talented students into STEM fields, particularly underrepresented students who show potential for college success, and

2) integrate mathematics more thoroughly into STEM curriculum with particular emphasis in the life sciences.

Proactive recruiting combined with support provided by the MLS program could greatly increase:

(a) Number of students who begin with the intent of seeking a conceptually interdisciplinary STEM education, and/or

(b) Number of students who decide early on in their undergraduate career to add a second major or a minor.

MLS Program @ MU: Benefits

Need-based scholarships for all four years.

Multiple faculty mentors from a variety of disciplines.

Participation in the MLS FIG during the first year.

- English 200 “Scientific Literature and Rhetorik”
- MLS Proseminar I (3h; Year 1, fall & spring)

A faculty-guided research project during the summer and into the second year.

- MLS Proseminar II (1h; Year 1, summer)
- MLS Proseminar III (1h; Year 2, fall & spring)

MLS Program @ MU: Assessment

Internal Program Assessment *throughout the program.*

FS09 The 2009 Fellows start

FS10 The 2010 Fellows start

SP11 Year-2 External Evaluation {2-days, 2 reviewers}

FS11 The 2011 Fellows start

FS12 The 2012 Fellows start

FS13 The 2013 Fellows start

We are here!

SP14 Year-5 External Evaluation {2-days, 2 reviewers}

Proseminar Ia: Year 1, Fall Semester

Integrated Topics Course

PRISM-MLS Proseminar - MU

faculty.missouri.edu/~glaserr/prism/fall2009.html

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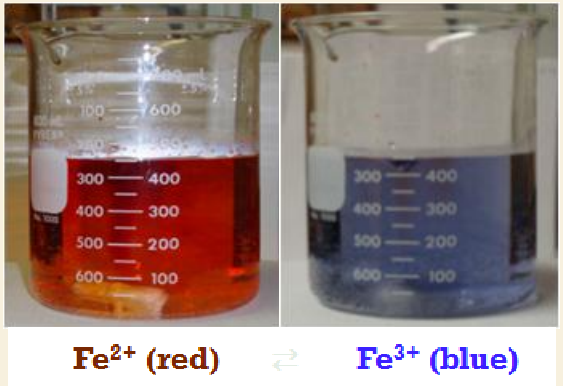
PRISM-MLS Proseminar, Fall Semester 2009

Week	Module	Format	Location	Faculty	Materials
Aug. 24	MLS Opener	Informal Meeting	572 LSC	All	Pizza!
Aug. 31	Excel Workshop	Comp. Lab.	Schlundt 105	Rainer Glaser	Assignment, XLS Worksheets 1, 3a & 3b.
Sep. 7	**LABOR DAY**				
Sep. 14	Bacterial Fluctuation	Bio. Lab. I	125 LSC	George Smith & Miriam Golomb	Handout
Sep. 21	Bacterial Fluctuation	Bio. Lab. II	125 LSC	Miriam Golomb	
Sep. 28	Philosophy: "Darwin" *vs.* "Lamarck"	Lecture, Discussion	572 LSC	Andrew Ariew	Reading, Pizza!
Oct. 5	Business: Spring Semester Courses	Discussion	Math 111	Dix Pettey et al.	
Oct. 12	Allometric Scaling I: Movie Monsters and Elementary Scaling Principles	Lecture, Discussion	Math 111	Dix Pettey	Images, Video, Assignment
Oct. 19	Allometric Scaling II: Bone Strength, Metabolism, and Fractal Structures	Lecture, Discussion	Math 111	Dix Pettey	Images, Handout
Oct. 26	Poisson Distribution: Statistics	Lecture w/ Excel	Math 12	Stephen Montgomery-Smith	Handout
Nov. 2	Beer's Law I: Exponential Functions and Differential Equations	Lecture w/ Excel	Math 12	Nakhle Asmar	Handout
Nov. 9	Beer's Law II: Curve Fitting	Lecture w/ Excel	Math 12	Nakhle Asmar	XLS Worksheet
Nov. 16	Chemical Kinetics I. Delayed Consequences and Oscillations	Lecture w/ Video	Math 111	Rainer Glaser	Handout (PDF) of PPTX
Nov. 23	**THANKSGIVING BREAK**				
Nov. 30	Chemical Kinetics II. Experimentation	Chem. Lab.	125 LSC	Rainer Glaser & Stephanie Miller	
Dec. 7	Chemical Kinetics III. Mathematical Kinetics	Lecture w/ Excel	Math 111	Carmen Chicone	Handout, XLSX Worksheet

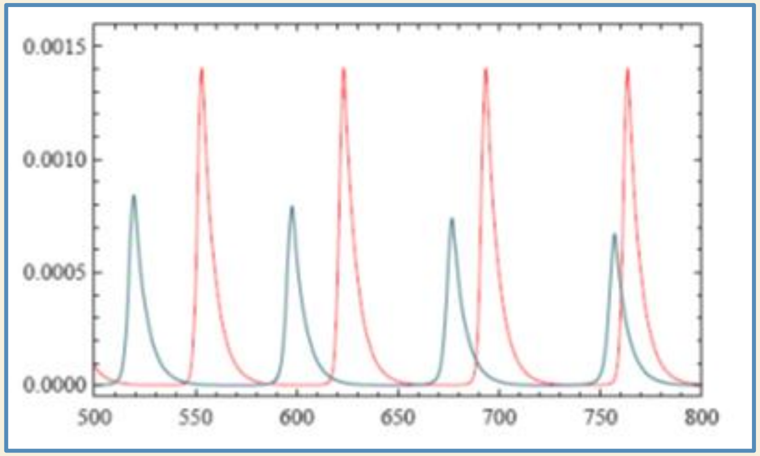
Chemical Kinetics: Chemistry Lab



Ferroin-Cat., Stirred BZ Reaction

MLS Fellows 2009-2010

Chem. Kin.: Mathematical Simulation



MLS Fellows 2009-2010

Proseminar Ib: Year 1, Spring Semester

Presentations by Potential Mentors

faculty.missouri.edu/~glaserr/prism/spring2010.html

PRISM-MLS Proseminar, Spring Semester 2010

Date	Event	Purpose	Location
Jan. 25	Ms. Vicky Riback-Wilson, Coordinator, Fellowships Office	Scholarship Opportunities	22 Math
Feb. 1	Dr. George Smith, Curators Professor of Biology "Fluctuation Tests: The Next Generation"	Prospective Research Adviser	322 Tucker
Feb. 8	Dr. Matthew Gompper, Professor of Forestry, Fisheries, and Wildlife "Parasite Distributions in Missouri Racoon Populations"	Prospective Research Adviser	322 Tucker
Feb. 15	Dr. Zachary Ernst, Associate Professor of Philosophy "Game Theory and the Nash Equilibrium"	Prospective Research Adviser	322 Tucker
Feb. 22	Dr. D. Cornelsion, Professor of Biological Sciences "Muscle Satellite Cells"	Prospective Research Adviser	322 Tucker
March 1	Dr. Kannappan Palaniappan, Lapierre Assoc. Prof of Computer Science "Biomedical Imaging"	Prospective Research Adviser	322 Tucker
March 8	Dr. Jeff Rouder, Professor of Psychological Sciences	Prospective Research Adviser	322 Tucker
March 15	Dr. Chris Pires, Professor of Biological Sciences "Using Next-Gen Sequencing to Elucidate Plant Phylogenetics"	Prospective Research Adviser	322 Tucker
March 22	Dr. Linda Blockus, Director, MU Undergraduate Research "Summer Undergraduate Research Opportunity Program"	Research Opportunities	322 Tucker
March 29	SPRING BREAK		322 Tucker
April 5	Dr. Bill Allen, Professor of Journalism	Prospective Research Adviser	322 Tucker
April 12	Missouri Life Sciences Week	View LS Research Posters	McQuinn Atrium
April 19	Dr. C. Chicone, Prof. of Math. & Dr. R. Glaser, Prof. of Chem. "Oscillating Reactions in Chemical and Biological Systems"	Prospective Research Adviser	322 Tucker
April 26	Dr. Keith Schneider, Professor of Psychological Sciences "Functional Imaging of the Brain"	Prospective Research Adviser	322 Tucker

Student-Faculty Interactions…

…formal and informal

MLS Fellows 2009-2010

Proseminar III: Year 2, Fall & Spring

Research Seminars by Second-Year MLS Fellows

MLS Proseminar III -- Res. Se

faculty.missouri.edu/~glaserr/prism/MLS2spring2012.html

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MATH1602-1 (1h credit)

PRISM-MLS Proseminar III -- Research Seminar for Second-Year MLS Students (2010 Fellows) - SP12 Schedule

Date	Speaker(s) & Topic	Mentor(s)	Location	SC-Item
Jan. 17	Planning & Organization (via email) Read Syllabus and Evaluation Rubric.	Dr. Rainer Glaser, Chemistry	-	Syllabus 3.0 Evaluation Rubric 2.0
Jan. 24	No Meeting	-	-	-
Jan. 31	Marielle Lefloch "The effect of hormones on Tramp-C2 prostate cancer cell growth."	Dr. Dennis Lubahn, Biochemistry	Math 110, 5-6 pm	-
Feb. 7	Jeremy Clincy "Meibomian Gland Development in Mice"	Dr. Lixing Reneker, Dept. of Ophthalmology, MU, School of Medicine	Math 110, 5-6 pm	-
Feb. 14	Ryan Roach "Using Individual Movement Data to Map Population Distributions: a Simulation Study"	Dr. Ricardo Holdo, Dept. of Biological Sciences	Math 110, 5-6 pm	-
Feb. 21	Chelsea Nichols "Materials Characterization of Explanted Hernia Mesh"	Dr. Sheila Grant, Dept. of Biological Engineering	Math 110, 5-6 pm	-
Feb. 28	Rainer Glaser "Working with Primary Literature I"	-	Math 110, 5-6 pm	Bring your laptops!
March 6	Jessica Boateng "The role of outer membrane protein Lav in autoaggregation and dispersal of nontypeable Haemophilus influenzae."	Dr. Miriam Golomb, Dept. Biol. Sci.	Math 110, 5-6 pm	-
March 13	Austin Yates "Programming and Utilizing the Fast Fourier Transform"	Dr. Montgomery-Smith, Dept. of Math.	Math 110, 5-6 pm	-
March 20	Anh Le "Computing Probabilities for Luria-Delbruck Experiment"	Dr. Montgomery-Smith, Dept. of Math.	Math 110, 5-6 pm	-
March 27	**SPRING BREAK**	-	-	-
April 3	Dr. George Smith "Symmetry principles in the construction of big viruses from	Dept. of Biol. Sciences	Math 110, 5-6 pm	-

Proseminar III:
Year 2, Fall & Spring

Research Seminars by Second-Year MLS Fellows

Syllabus

University of Missouri-Columbia, FS12

MATH1602: PRISM-MLS Proseminar III

SYLLABUS SYLLABUS SYLLABUS

Professors:	Drs. Rainer Glaser and Dix Pettey
Email:	glaserr@missouri.edu; petteyd@missouri.edu
Home Page:	http://faculty.missouri.edu/~glaserr
Seminar:	Monday, 4-4:50 pm, 110 Math. Bldg.
Office Hours:	Immediately following seminar, and by appointment
Course Web Site:	http://faculty.missouri.edu/~glaserr/prism/MLS2fall2012.html

MATH1602-1 (1h credit) is the PRISM-MLS Proseminar III, that is, the research seminar for second-year MLS students. Enrollment is mandatory for all 2011 Fellows in FS12 and SP13. The course will be graded based on attendance and performance; see back page for details.

Course Objectives: Learning and practice of elements of scientific communication and peer review. Scientific writing: text, tables, schemes & figures; Methods for locating chemical information and proper citation; Summarizing, paraphrasing and plagiarism; Structuring a scientific paper; Approaches to data analysis; Recognizing and communicating significance and meaning; Responsible authorship.

Course Materials

(1) Selected course materials will be posted on the course web site.

(2) RECOMMENDED. *From Research to Manuscript: A Guide to Scientific Writing*. 2/e. Michael J. Katz. Springer: New York, **2009**. ($23.92; Amazon, accessed 08/06/12)

(3) RECOMMENDED. *The ACS Style Guide: Effective Communication of Scientific Information*. Anne M. Coghill and Lorrin R. Garson. American Chemical Society: Washington, D.C., **2006**. (Hardcover: $37.23; Amazon, accessed 08/06/12)

(4) FURTHER READING. *Write Like a Chemist: A Guide and Resource*. Marin S. Robinson, Fredricka L. Stoller, Molly Costanza-Robinson, and James K. Jones. Oxford University Press, USA: New York, **2008**. (Paperback: $38.85; Amazon, accessed 08/06/12).

(5) FURTHER READING. *Scientific Writing and Communication*. Hofmann, A. H. Oxford University Press, USA: New York, **2009**. (Paperback: $25.39; Amazon, accessed 08/06/12).

Research Seminars by Second-Year MLS Fellows

Grading Philosophy

This emphasis on equal time between presentation and scientific discussion is a stratagem of this course. We want open, frank discussion and cross- and interdisciplinary brainstorming, exchange and education. Your performance will be assessed following this spirit. Your grade in this research seminar will be affected by your attendance, your presentation (if any), your peer review performance, and your performance as a discussant. This grading scheme reflects a shift from the traditional assessment of the speaker to an assessment of members of the learning community.

The "A" needs to be earned: Start at grade "B+"
Attendance: One unexcused absence OK. Each unexcused absence: 2 steps down.
Presentation: Above average by peer review: 1 step up.
Peer Reviewer Performance: Assessed by instructor: 1 step up or down.
Discussant Performance: Assessed by instructor: 1 step up or down, or neutral.

Details: http://faculty.missouri.edu/~glaserr/prism/MLS_Syllabus_FS12.pdf

Rubric-Based Peer Review 1:

Assess Mathematics & Science Content

Peer Review of Presentation by ________________________ (presenter's name).
Evaluator's Peer Reviewer Number ___.

	Beginning, 1	Developing, 2	Accomplished, 3	Exemplary, 4	Score
Introduction & Context	Significance and importance of overall project aims and goals are unclear. Relevance of the specific project not established.	Significance and importance are explained in the context of ongoing research in the group. Pertinent references are cited.	Significance and importance are explained and justified in the context of ongoing research in the group. Greater context lacking.	The general significance and the broader importance are explained and justified of the general context and of the specific research project.	/4
Science Problem, Math Problem, and Their Integration	Research problem defined vaguely. Science and/or math challenges not isolated. Unclear whether the project presents cross- and/or inter-disciplinary challenges. Hypothesis is missing. Specific aims are missing.	Research problem is defined but its science and/or math challenges are not well characterized. Cross- and/or inter-disciplinary challenges remain unclear. Hypothesis is formulated. Specific aims are missing.	Science and math problems are stated but not well separated. Cross- and/or inter-disciplinary issues stated. Hypothesis is formulated and specific aims are listed.	Science and math problems are clearly stated separately, without jargon and/or undefined technical terms. Cross- and/or inter-disciplinary nature of the project is clearly stated. Hypothesis is formulated and specific aims are listed regarding science and math.	/4
Materials & Methods	Chaotic description of research. Too many issues lacking precision or not addressed. Next to impossible to reproduce.	About 75% of essentials elements described with pertinent references. Sequence less than ideal. Might be able to reproduce.	About 90% of essential components are described with pertinent references. Sequence is reasonable. Should be able to reproduce.	All materials, equipment, known procedures & algorithms, extant software described with references. Will be able to reproduce.	/4
Results & Discussion	Confusing presentation of research performed. Lacking comparative discussion of new and prior results.	Comprehensible presentation of research performed. No clear separation between new and prior results.	Clear presentation of research performed. Clear separation between new data and reference materials.	Clear & concise presentation of research performed and of results. Discussion of possible errors.	/4
Conclusion	The statements in "Conclusion" do not correspond to the hypotheses stated in "Introduction".	No clear separation between summary of new results and assessment of hypotheses. Broader impact missing.	No clear separation between summary of new results and assessment of hypotheses. Overreaching interpretation.	Summary of factual results. Evaluations of hypotheses. Deductions about impacts are reasonable and justified.	/4
				Content Total (Max. 20)	

Continued on back page!

Rubric-Based Peer Review 2:

Assess Student's Presentation Skills

	Beginning, 1	Developing, 2	Accomplished, 3	Exemplary, 4	
Eye Contact	Does not attempt to look at audience at all, reads notes the entire time.	Only focuses attention to one particular part of the class, does not scan audience.	Occasionally looks at someone or some groups during presentation.	Constantly looks at someone or some groups at all times.	/4
Mannerism, Gestures, etc. Counts 0.5	Underprepared and incompetent, and it shows.	An honest attempt. Not on top of the material as yet.	Self-assured, mostly competent, responsible.	Calm, optimistic, self-assured, and competent.	/2
Vocal. Pauses (uh, well, um) Counts 0.5	More than 10. Irritating.	Slightly irritating.	Noticeable.	Fine.	/2
Enthusiasm	Shows no interest in topic presented.	Shows some interest toward topic presented.	Occasionally shows positive feelings about topic.	Demonstrates a strong positive feeling about topic during entire presentation.	/4
Slides	Some key elements missing. Slides are poorly prepared.	Outline is recognizable but incomplete. Some slides lack in form and/or content.	All key elements are present. One slide lacks in form or content.	Slides are correct in form and content, and enhance the presentation.	/4
Timing	Cannot finish in time or insufficient material.	Insecure about timing. Frequent adjustments of presentation speed.	Finished on time. But slow at beginning and/or rushed toward the end.	Appropriate number of slides presented at a speed that allowed following.	/4
				Presentation Total (Max. 20)	
				Overall (Max. 40)	

Constructive Comments to Improve Slides:	Constructive Comments to Improve Oral Presentation:

Minute Papers: Classroom Assessment

Assessing Assessing Prior Knowledge, Recall and Understanding

1. Background Knowledge Probe
2. Focused Listing
3. Misconception/Preconception Check
4. Empty Outlines
5. Memory Matrix
6. Minute Paper
7. Muddiest Point

"The *Minute Paper* and the *Muddiest Point*, though extremely simple, focus on understanding, a somewhat deeper level of learning than simple recall. By asking students to judge what was clear and what was not, or what was most important and what they still have questions about, the CATs require learners to engage in simple acts of meta-recognition, to reflect on and assess their own understanding of the content they are learning." (Angelo and Cross, p.120)

Thomas A. Angelo, K. Patricia Cross, *Classroom Assessment Techniques: A Handbook for College Teachers*. Jossey-Bass, 2/e, 1993. Sec. 7 on *Techniques for Assessing Course-Related Knowledge and Skills*, Item 6 on *Minute Paper*.

Peer Review Outcomes: Scores

Peer Review Evaluation Criterium	Speaker (RN)												
	FS11				SP12								
	5	7	8	28	3	9	12	16	19	27	43	Ave.	σ
Introduction & Context	3.9	3.5	3.5	3.3	3.7	3.0	3.8	4.0	3.5	2.6	3.9	3.5	0.4
Science/Math/Integration	3.7	3.5	3.6	2.9	3.7	2.4	3.0	3.8	3.3	3.2	3.4	3.3	0.4
Materials and Methods	3.0	3.4	3.4	3.3	3.5	2.4	3.8	3.8	3.5	3.4	3.9	3.4	0.4
Results and Discussion	3.7	3.5	3.9	3.5	3.6	3.4	4.0	3.8	3.5	3.0	3.8	3.6	0.3
Conclusion	3.8	3.8	3.7	3.4	3.8	4.0	3.6	3.9	3.8	2.9	3.9	3.7	0.3
Content Total (Max. 20)	18.0	17.7	18.1	16.2	17.0	15.2	18.2	19.1	17.5	15.1	18.8	17.3	1.3
Eye Contact	3.8	3.5	3.8	3.6	3.7	2.4	3.4	4.0	3.8	4.0	3.1	3.5	0.5
Mannerism, etc. (x0.5)	1.9	1.7	1.9	1.9	2.0	1.5	1.9	1.9	1.8	1.6	1.7	1.8	0.2
Vocal. Pauses (uh, …) (x0.5)	1.8	1.9	1.8	1.6	1.8	1.9	1.5	1.9	1.4	1.8	1.9	1.7	0.2
Enthusiasm	3.7	3.8	3.7	3.6	3.9	2.3	4.0	3.8	3.3	3.6	3.5	3.5	0.5
Slides	3.6	3.9	3.6	3.4	3.5	3.1	3.8	3.6	3.1	3.4	3.6	3.5	0.2
Timing	3.9	3.4	3.7	3.9	3.8	3.9	3.8	3.8	4.0	3.3	3.8	3.7	0.2
Presentation Total (Max. 20)	18.6	18.2	18.6	18.3	18.6	15.0	18.4	18.9	17.3	17.0	17.3	17.8	1.1
Overall Total (Max. 40)	36.6	35.9	36.6	34.5	35.6	30.3	36.6	38.0	34.8	32.7	36.0	35.2	2.1
Sigma	2.1	1.8	2.9	3.3	4.2	4.9	3.4	2.7	4.0	3.5	3.0	3.3	0.9
Minimum	32.5	34.0	30.0	28.0	27.0	21.5	31.5	33.5	27.5	30.0	32.0	29.8	3.6
Maximum	39.0	39.0	40.0	38.0	40.0	37.0	40.0	40.0	40.0	40.4	40.0	39.4	1.0
Number of Reviewers	13	13	15	13	8	7	5	8	8	7	8	9.5	3.3

Numbers in Color: Below 87.5 %; Red: < 3.5/4.0; Orange: < 1.75/2.0.

Areas that need more attention:

Science/Math/Integration, Materials & Methods, Free Speech

Peer Review Outcomes: Comments

PRN	Presentation Content				Minute Paper			
	Ave.	σ	Min.	Max.	Ave.	σ	Min.	Max.
28	28.2	14.2	10	53	44.7	30.0	10	113
5	21.1	14.4	4	49	50.9	32.5	17	125
7	25.7	15.8	11	54	52.6	32.5	13	128
8	18.5	14.4	0	56	55.7	26.8	21	105
28	28.2	14.2	10	53	44.7	30.0	10	113
3	14.4	8.5	3	29	42.8	12.1	19	58
9	23.6	10.9	9	39	48.8	12.9	39	67
12	11.3	5.0	4	15	67.8	26.2	30	102
16	13.6	4.8	6	22	65.1	36.1	30	118
19	20.3	14.2	7	50	74.6	32.3	28	130
27	15.3	12.1	5	35	45.1	17.8	25	76
43	18.5	8.1	7	28	60.4	30.0	28	112

Numbers in Red considered too low.

Areas that need more attention:

Scope of written justification of PR scores: Averages & Min. Values too low!

Scope of written text in Minute Papers: Average OK; some Min. Values too low!

Minute Papers Version 2.0

Minute Paper by ________________; Peer Reviewer Number __. Date: _______.
Regarding the Presentation by ________________________ (presenter's name).

Respond to the two questions in no more than five minutes immediately following the presentation. You may write some items during the presentation. Separate your thoughts clearly. Answer in words, phrases, or short sentences. Aim to address at least three items in each answer. Be brief and concise. It is expected that you answer in about 50 words or more (combined answers). Answers with a combined word count of less than 25 words are insufficient.

What were the most important things you learned from this presentation?	What important questions remain unanswered?

Evolving Implementation

Formalize the Minute Paper

In future, we will use a handout with description of expectations.

Inform Students About Previous Outcomes

Sharing assessment data from previous seminars with current students will clarify student expectations. (Example: Improve word counts of written comments).

Math/Science Integration & Faculty Development

Research seminar instructor meets every student before & after (s)he presents in the seminar; this guidance is of some value. To really advance this aspect requires faculty development. As a first step in this direction, we aim to increase the participation of mentors in the seminars of their students.

Scientific Communication in the Disciplines

Formal instruction in scientific communication is essential. The number of units of formal instruction on the science process and scientific writing will be increased.

Program Outcomes: 2nd Year MLS

5. Tell me what you enjoyed about your second-year in the MLS program. (From 2011-2012 Annual Report)

- I enjoyed most when we got into a discussion and it was well-mediated so that we could have an intelligent respectful debate. I always learned from what other people had to say and my own beliefs were challenged so that I had to defend them or change them.
- I really enjoyed the fact that the students got to really direct the proseminar course for the second-year of the program, students selected topics they wanted to discuss and also focused heavily on presenting their own research.
- Meeting with other students that have similar interests. Directing presentations and discussions towards subject of our choosing, like during Pi Day.
- Having a research opportunity available to me.

Program Outcomes: 2nd Year MLS

5. Tell me what you enjoyed about your second-year in the MLS program. (From 2011-2012 Annual Report)

- Being able to keep in touch with the mentors and students as well as seeing how the projects of each student was progressing.
- The conversations our courses generated.
- The ongoing support of the program and getting to learn about new and continuing research going on within the program was a great opportunity.
- Listening and learning about other fellows' research, even though mine was done.
- I enjoyed seeing the other MLS fellows who are in my classes and having a group to turn to for questions concerning classes, research, pre-med, etc.
- I liked being in contact with people from other disciplines and discussing scientific things with them. It breaks the science people out of their bubble to hear from me as well. I am thankful for the relationship with faculty because they are reputable people that I could use for letters of recommendation when I am applying for teaching jobs.

Program Outcomes: MLS Program

6. Please indicate the extent to which you agree with each of the following statements based on your experiences with the MLS program. (Summer 2012)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I enjoy thinking about how different fields approach the same problem in different ways.					x
In solving problems, I often seek information from experts in other academic fields.				x	
Given knowledge and ideas from different fields, I can figure out what is appropriate for solving a problem.				x	
I am more readily able to see connections between mathematics and the life sciences.					x
I can use what I have learned in another setting or to solve a new problem.					x
If asked, I could identify the kinds of knowledge and ideas that are distinctive to different fields of study (chemistry, biology, mathematics, etc.)				x	

Program Outcomes: MLS Program

6. How has the MLS program helped you see the connections between mathematics and the life sciences? (From Summer 2012 Assessment)

“In every way possible, it has.”

“Yes, infinitely more. My career definitely will be somewhere in this field and I look forward to it.”

“Yes, MLS made that connection very clear through the proseminars.”

“I mainly saw the connections with the research because you can research anything biology-related but you need math to make sense out of your data.”

“I see how big of an impact using models in areas of the life sciences is. Math is a way to examine small parts of the life sciences and to quantify it.”

THE JOURNAL OF PHYSICAL CHEMISTRY A

Article

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Disproportionation of Bromous Acid HOBrO by Direct O-Transfer and via Anhydrides $O(BrO)_2$ and $BrO{-}BrO_2$. An Ab Initio Study of the Mechanism of a Key Step of the Belousov–Zhabotinsky Oscillating Reaction

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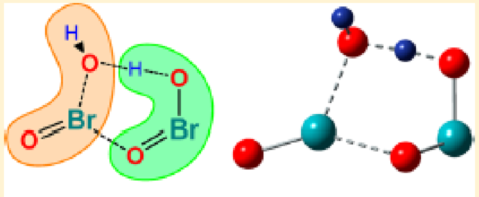
Supporting Information



2 HOBrO ⇌ HOBr + $HOBrO_2$

ABSTRACT: The results are reported of an ab initio study of the thermochemistry and of the kinetics of the HOBrO disproportionation reaction 2HOBrO (2) ⇄ HOBr (1) + $HBrO_3$ (3), reaction (R4′), in gas phase (MP2(full)/6-311G*) and aqueous solution (SMD(MP2(full)/6-311G*)). The reaction energy of bromous acid disproportionation is discussed in the context of the coupled reaction system R2–R4 of the FKN mechanism of the Belousov–Zhabotinsky reaction and considering the acidities of HBr and $HOBrO_2$. The structures were determined of ten dimeric aggregates 4 of bromous acid, $(HOBrO)_2$, of eight mixed aggregates 5 formed between the products of disproportionation, $(HOBr)(HOBrO_2)$, and of four transition states structures 6 for disproportionation by direct O-transfer. It was found that the condensation of two HOBrO molecules provides facile access to bromous acid anhydride 7, $O(BrO)_2$. A discussion of the potential energy surface of Br_2O_3 shows that $O(BrO)_2$ is prone to isomerization to the mixed anhydride 8, $BrO{-}BrO_2$, and to dissociation to 9, BrO, and 10, BrO_2, and their radical pair 11. Hence, three possible paths from $O(BrO)_2$ to the products of disproportionation, HOBr and $HOBrO_2$, are discussed: (1) hydrolysis of $O(BrO)_2$ along a path that differs from its formation, (2) isomerization of $O(BrO)_2$ to $BrO{-}BrO_2$ followed by hydrolysis, and (3) $O(BrO)_2$ dissociation to BrO and BrO_2 and their reactions with water. The results of the potential energy surface analysis show that the rate-limiting step in the disproportionation of HOBrO consists of the formation of the hydrate 12a of bromous acid anhydride 7 via transition state structure 14a. The computed activation free enthalpy $\Delta G_{act}(SMD)$ = 13.6 kcal/mol for the process 2·2a → $[14a]^\ddagger$ → 12a corresponds to the reaction rate constant k_4 = 667.5 M^{-1} s^{-1} and is in very good agreement with experimental measurements. The potential energy surface analysis further shows that anhydride 7 is kinetically and thermodynamically unstable with regard to hydrolysis to HOBr and $HOBrO_2$ via transition state structure 14b. The transition state structure 14b is much more stable than 14a, and, hence, the formation of the "symmetrical anhydride" from bromous acid becomes an irreversible reaction for all practical purposes because 7 will instead be hydrolyzed as a "mixed anhydride" to afford HOBr and $HOBrO_2$. The mixed anhydride 8, $BrO{-}BrO_2$, does not play a significant role in bromous acid disproportionation.

Published online 8/9/12

Multi-Equilibria Problems for Mixtures of Acids and Their Conjugated Bases

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To be submitted July '13

$H_2O \rightleftarrows H^+ + OH^-,\ K_w$ (eq. 1)

$H_2A \rightleftarrows H^+ + HA^-,\ K_{a1,1}$ (eq. 2)

$HA^- \rightleftarrows H^+ + A^{2-},\ K_{a1,2}$ (eq. 3)

$HB \rightleftarrows H^+ + B^-,\ K_{a2}$ (eq. 4)

$$z^4 + (K_{a1} + \alpha)z^3 + (-K_w + K_{a1}(K_{a2} + \alpha - \beta))z^2$$
$$-K_{a1}(K_w - K_{a2}\alpha + 2K_{a2}\beta)z \; - \; K_{a1}K_{a2}K_w = 0$$

$$\frac{d[H^+]}{dt} = k_{wf} - k_{wb}[H^+][OH^-] + k_{11f}[H_2A] - k_{11b}[H^+][HA^-]$$
$$-k_{12b}[H^+][A^{2-}] + k_{12f}[HA^-] + k_{2f}[HB] - k_{2b}[H^+][B^-] \quad \text{(eq. 5)}$$

$$\frac{d[OH^-]}{dt} = k_{wf} - k_{wb}[H^+][OH^-] \quad \text{(eq. 6)}$$

$$\frac{d[H_2A]}{dt} = -k_{11f}[H_2A] + k_{11b}[H^+][HA^-] \quad \text{(eq. 7)}$$

$$\frac{d[HA^-]}{dt} = k_{11f}[H_2A] - k_{11b}[H^+][HA^-] + k_{12b}[H^+][A^{2-}] - k_{12f}[HA^-] \quad \text{(eq. 8)}$$

$$\frac{d[A^{2-}]}{dt} = k_{12f}[HA^-] - k_{12b}[H^+][A^{2-}] \quad \text{(eq. 9)}$$

$$\frac{d[HB]}{dt} = -k_{2f}[HB] + k_{2b}[H^+][B^-] \quad \text{(eq. 10)}$$

$$\frac{d[B^-]}{dt} = k_{2f}[HB] - k_{2b}[H^+][B^-] \quad \text{(eq. 11)}$$

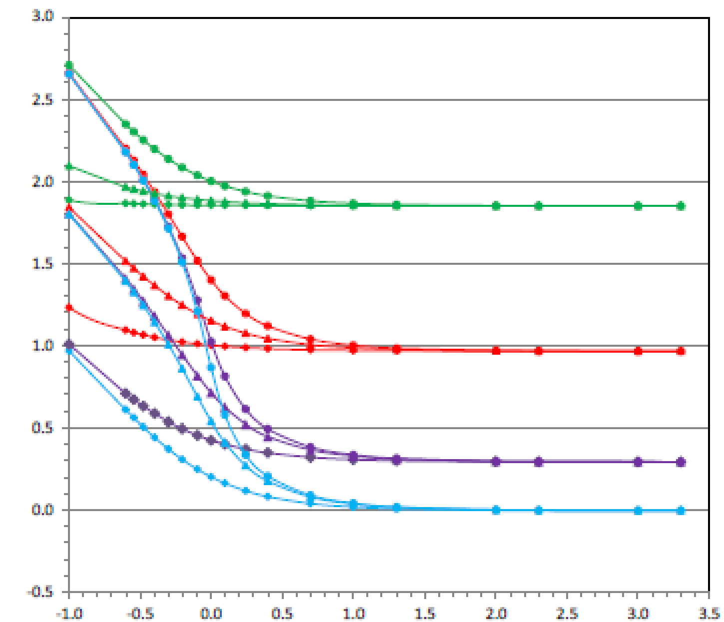

Figure 2. *pH*-Values of dilute aqueous H_2SO_4 containing bromate as a function of log(R_0) and for various acid dissociation constants K_a($HBrO_3$). Color indicates initial concentration of sulfuric acid: $[H_2SO_4]_0 = 0.01$, green; $[H_2SO_4]_0 = 0.1$, red; $[H_2SO_4]_0 = 0.5$, purple; $[H_2SO_4]_0 = 1.0$, blue. Marker shape indicates acid dissociation constants K_a($HBrO_3$): $pK_a = 0$, diamonds; $pK_a = 1$, triangles; $pK_a = 2$, circles.

Conclusion

6. How has the MLS program helped you see the connections between mathematics and the life sciences? (From Summer 2012 Assessment)

“In every way possible, it has.”