Challenges for Women in Quantum Chemistry

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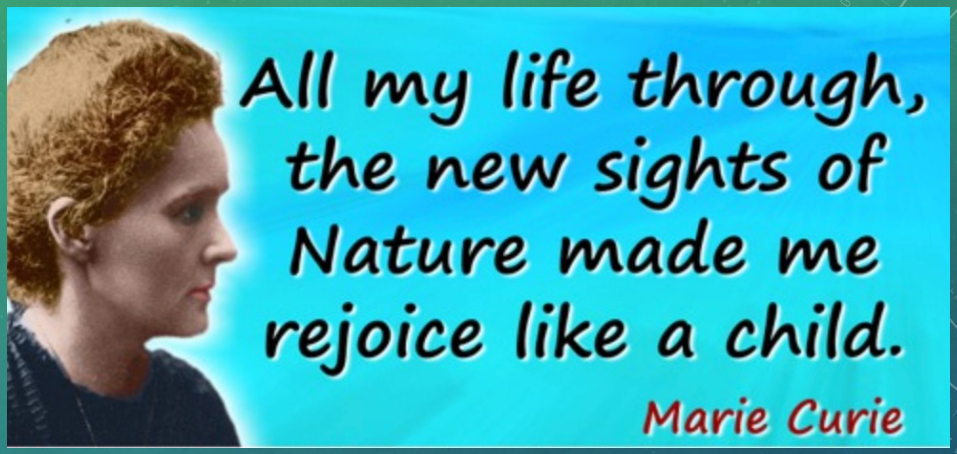
INSTITUTE FOR ADVANCED STUDIES (IAS)

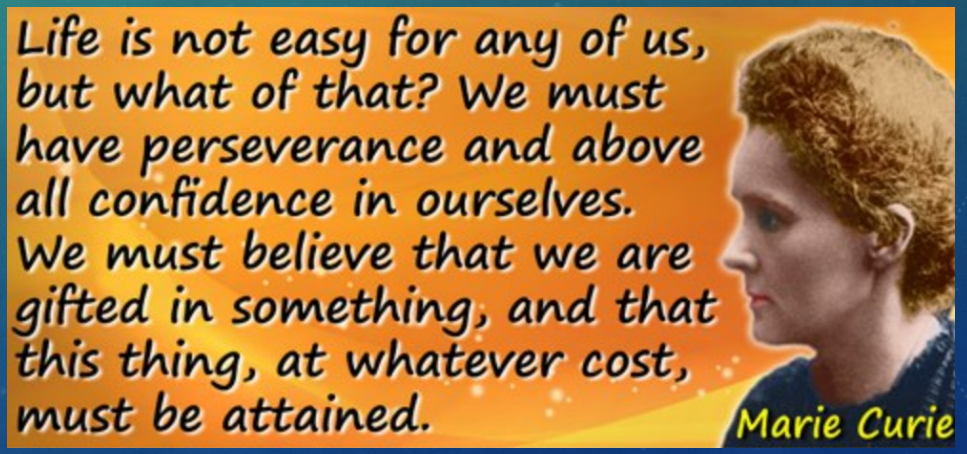
Most important remarks

- Pursuing a scientific career poses challenges to everyone, regardless of personal characteristics, though it is more difficult for some than for others.
- The barriers against participation in science by women have been dropping on a generation-by-generation basis.
- This talk provides a personal cultural and historical view:
  I will mention barriers that my friends and I have faced during our careers.
- The efforts to overcome any obstacles that remain are worth it!
- All of the scientists at the University of Luxembourg are tremendously impressive to me, and I wish you all the best!

Marie Curie has cast a long shadow

https://tasteofscience.org/san-francisco-events/marie-curie-150th-birthday





Quotations from https://todayinsci.com/C/Curie_Marie/CurieMarie-Quotations.htm

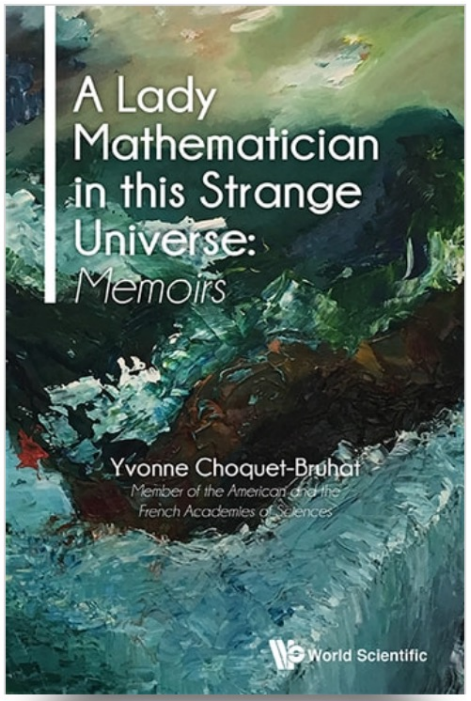
The situation for women in science in the EU and in Britain may have been better than in the US. In Cambridge as a Ph.D. student, I heard lectures by two women scientists, Ruth Lynden-Bell and Yvonne Choquet-Brouhat.

Ruth Lynden-Bell

Professor Ruth Lynden-Bell FRS
Fellow Elected 2006

Yvonne Choquet-Bruhat

Member of the French Academy of Sciences, elected in 1979



Cultural and recent historical view of the challenges for women in science and engineering

Personal examples that illustrate the challenges for women in quantum chemistry in the US, who grew up in the 1950's or later

Focus on women in theoretical chemistry in Michigan

Professor Evelyn Goldfield
Professor Katharine Hunt
Professor Angela Wilson

We were born about 15 years apart

First, Early scientific education: High-school and college

EVELYN HARRIET MAYER

Laughter is the universal language of mankind.

Evi . . . Tarheel . . . L.R.G. . . . little brother Larry . . . mail crew . . . Summer '58 . . . Northwoods gang . . . "Hey Enid" . . . T. in U.S. as O. . . . Sister-to-be, Janie . . . "Think we'll ever get 'em?" . . . in that particular area . . . telephone crew . . . Smitty, 4.

Spanish Club 3, 4; Latin Club 2; G.A.C. 1, 2, 3, 4; Dramatics Club 3, 4; Book Club 3, 4; Chorus 1.

WARREN L. McLANE

I bewitch sweet ladies with my words and looks.

Bowling . . . Burger Boy . . . 57 Plymouth . . . pet peeves: dead end streets; older sisters; and motorscooters . . . likes: loud radios, short girls, and custom cars . . . dislikes women drivers.

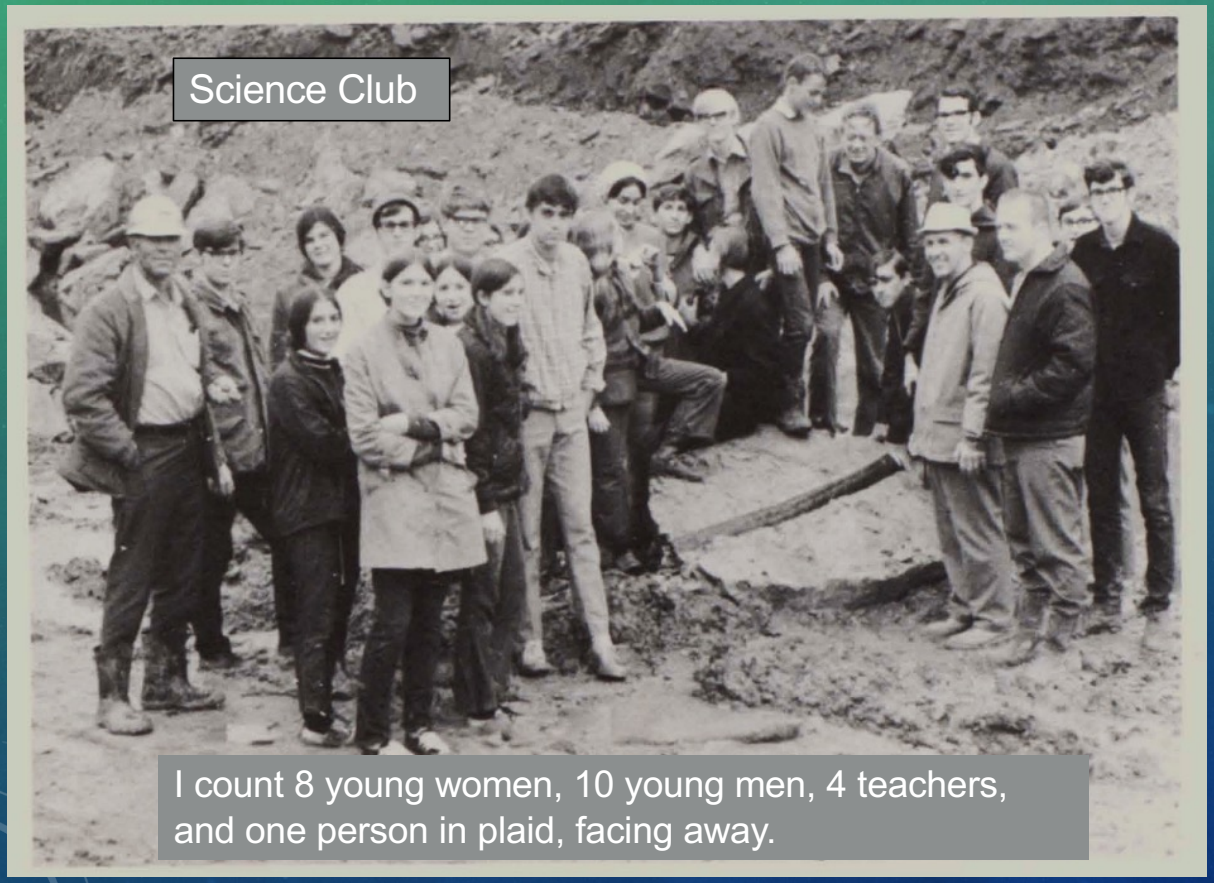
Football 3.

Evi Goldfield
National Science Foundation (NSF)
Program Officer in Chemical Theory, Models, and Computational Methods, Chemistry Division
14 years of service at NSF
Adjunct Professor, Wayne State University

Bexley High School Science Club

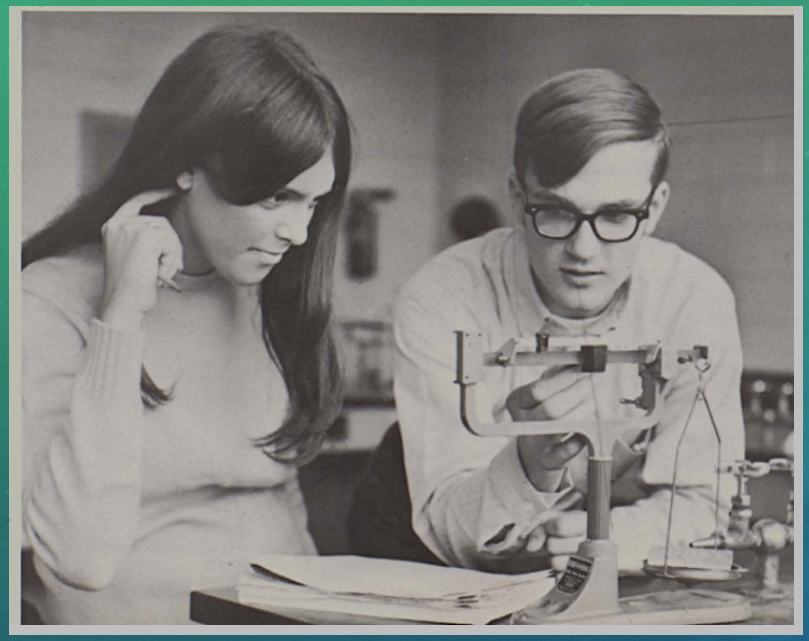
Bexley High School, Special evening math class

About 15 years later, at my high school (Hoover High School), also in Ohio

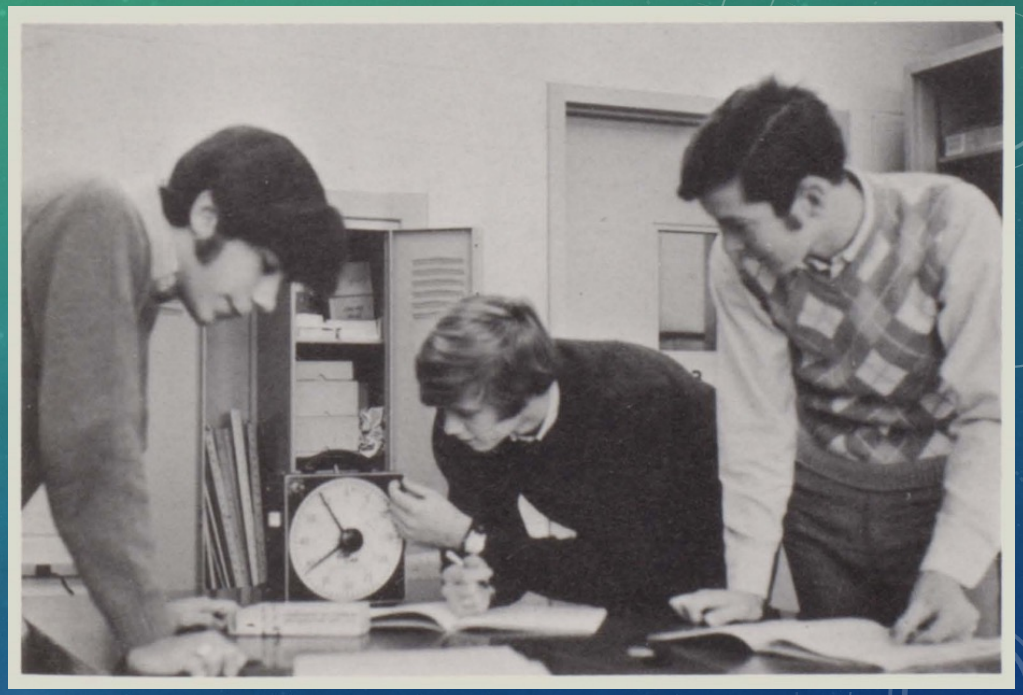


I count 8 young women, 10 young men, 4 teachers, and one person in plaid, facing away.

"[Male student] looks at plants."



[Male student] has discovered that helping [Female student] in chemistry lab will prepare him for his career in the field of science.



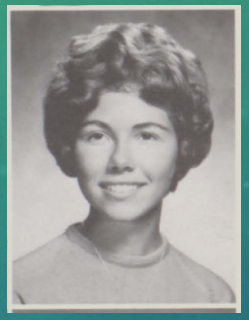
A physics lab experiment on centripetal force
I have no memory of this experiment!
I do remember (somewhat) an experiment to determine the charge-to-mass ratio of an electron

Evening Lecture
Dr. Richard Little
from a local
university

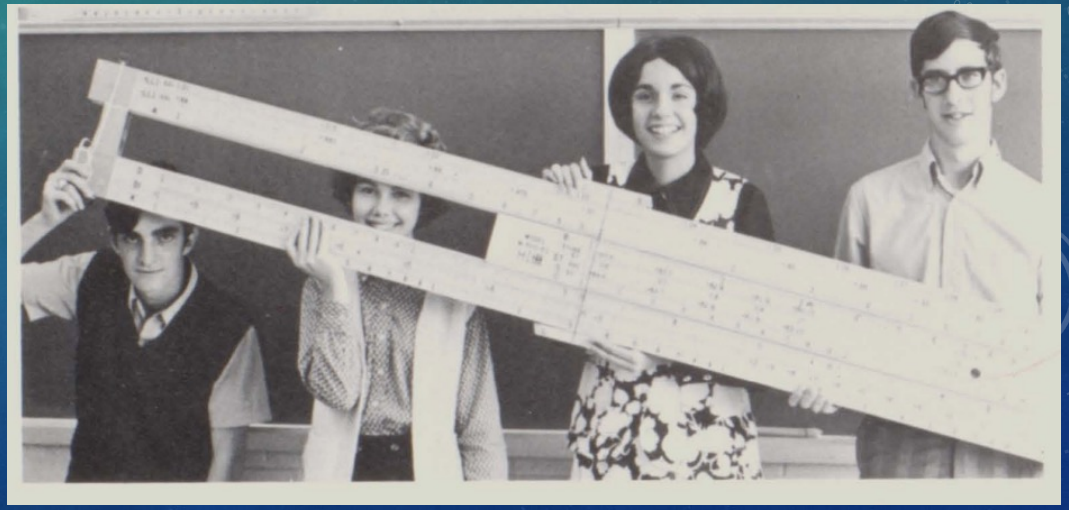
Evening math lectures had better participation by young women than 15 years before, in Bexley!

Dr. Little led a fascinating discussion on the subject of probability at a Math Club meeting. He proved that among thirty people there are two with the same birth date.

Science Club Officers (left) and Math Club Officers (right)



My high-school yearbook photo. Hair styles might have improved slightly since Evi's era?



“I am strong!
I am invincible!
I am woman!”

Helen Reddy

Also, Director of the Chemistry Division of the US NSF, the National Science Foundation

My colleague Professor Angela Wilson is the John A. Hannah Distinguished Professor in the Department of Chemistry at Michigan State University and Associate Dean for Strategic Initiatives in the College of Natural Science. She has been a major contributor to the development of correlation consistent composite approaches (ccCa methods). Beginning with her work with Thom Dunning and then continuing, she had produced many of the basis sets in current use in *ab initio* calculations. She is also working on density functional methods for heavy elements, including the actinides and lanthanides.

Angela graduated from high school in 1986, exactly 15 years after I graduated from high school. She attended high schools in two different states, first in Alabama and then in Washington.

As a junior (third year of high school), Angela was Vice President of her school's Math Club.

I counted 74 members of the Math Club in her yearbook photo, 36 girls and 38 boys. So, gender balance was nearly achieved at the high-school student level.

High school teachers
My experience and Angela Wilson's experience

Class	My Teachers # of Women	. . . 15 years	Angela's Teachers # of Women
Mathematics	0		5!
Earth Science	0		0
Biology	0		0
Microbiology	N/A		0
Chemistry	0		0
Physics	0		0

Choosing a College

At age 11, I started to think about the college I would like to attend. Caltech was my top choice. Caltech did not take women undergraduates at that time. In the Ivy League, neither did Harvard, Yale, Princeton, Columbia, Brown, Penn, nor Dartmouth. Seven of the eight Ivies were barred to women.

When did these colleges begin to accept women undergraduates?

Caltech 1969
Yale 1969
Princeton 1969
Brown 1971

Dartmouth 1972
Penn 1974
Harvard 1977
Columbia 1983

Cornell 1870
MIT 1882, but with more than 100 women by 1890, but only 19 earned the S.B.

Comments on college choice, posted on Twitter by Candace Dempsey, author, “former Microsoftie,” published in *Slate*, the *New York Times*, and the *Chicago Tribune*

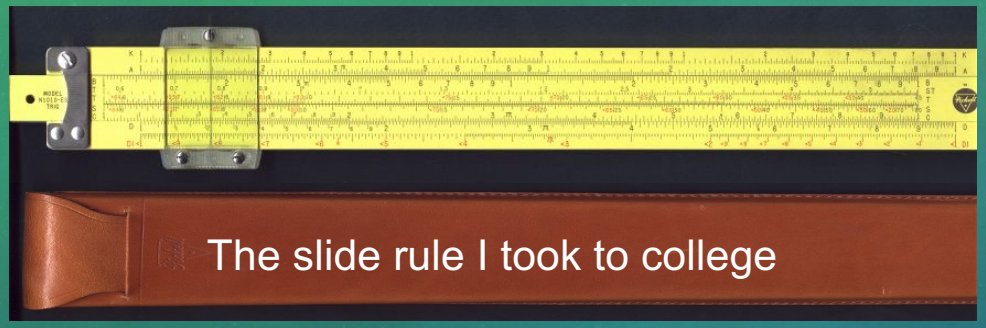
I came of age when the Ivy League was closed to women. Harvard, Yale, Dartmouth and the other elites claimed to chose only “the best and the brightest.” Somehow not a single woman qualified. They barred their doors to half the population, not because of inferior IQs, grades or test scores, but simply because of gender.

I’ve heard people claim this was not discrimination, because there were “sister schools” that did take women. But these were side campuses. Going to Radcliffe or any other "sister school" was never the same as going to the actual school.

It's bogus to say women were happy at Radcliffe and never dreamed of Harvard. The truth is only Radcliffe was on offer.

College administrators also made the argument that women didn’t actually want to go to the Ivy Leagues. We were *told* we didn’t want to be lawyers, doctors, athletes, newscasters, astronauts, and so on—anything but housewives, teachers and nurses. We were never *asked* what we wanted to do.

It was a different era!



The slide rule I took to college

Cost: $170

Programma 101

TRS-80, Cost: $599.95
In 2023 dollars: $2980

Cut and Paste was literally cut and paste! It is surprising that we could do anything!

University Professors
My experience and Angela Wilson's experience

Class	My Profs # of Women	. . . 15 years	Angela's Profs # of Women
Mathematics	0		0
Biology	0		0
Science Vocabulary	N/A		1
General Chemistry	0		0
Organic Chemistry	0		0
Inorganic Chemistry	0		0
Analytical Chemistry	0		0
Physical Chemistry	0		0
Quantum Mechanics	0		0
Physics	0		0
Computer Science	0		0

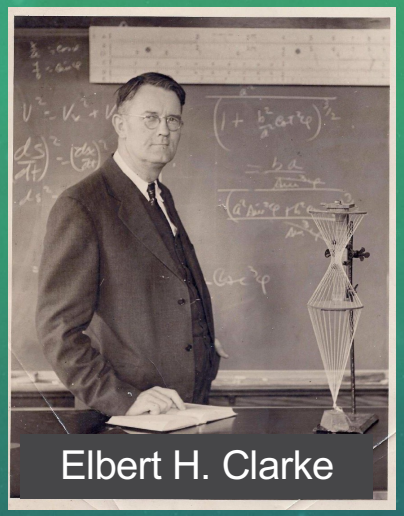
Having a very small number of women professors was quite common in US universities

State of the top 25 Chemistry Departments in the US, in 1976, from a study by Dudley Herschbach, Department of Chemistry and Chemical Biology, Harvard University, and Nobel Laureate for experiments in molecular beam scattering

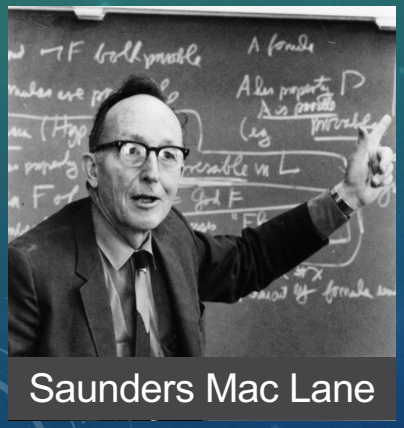
Of these 25 Departments, 20 had no women faculty members.
Four had one woman faculty member.
One had two women on the faculty!

All but one of the women were in biochemistry.
None of the women were tenured.

This was my second year in graduate school.



Elbert H. Clarke



Saunders Mac Lane

"The old-boy network functioned as follows: all the active mathematicians, such as Veblen at Princeton, Bliss at Chicago, or Birkhoff at Harvard (plus many others, such as Hildebrandt at Michigan) had pretty shrewd ideas as to the level of mathematical ability at many schools, and they also had quite detailed (but perhaps mistaken) knowledge of their own current products. So, when they heard that Oberlin College, or the women's college of North Erewhon, or the University of W had a vacancy, they knew which of their graduates would be an appropriate candidate there, and they acted accordingly."

Saunders Mac Lane, in *A century of mathematics in America, Part II*, edited by P. Duren, R. A Askey, and U. C. Merzbach, History of Mathematics 2, American Mathematical Society (Providence, RI), 1989.

Issues due to stereotyping

Does success have costs? The view of students in 1972

Matina S. Horner, *Journal of Social Issues* **28**, 157 (1972).

"After first term finals, John finds himself at the top of his medical school class."
"After first term finals, Anne finds herself at the top of her medical school class."

Written responses were collected from 88 men to the cue about John and from 90 women to the cue about Anne, "predominantly freshman and sophomore undergraduate students at a large midwestern university." They were in an introductory psychology class at the University of Michigan.

Responses about John

"More than 90% of the men in the study showed strong positive feelings" about John. They indicated "increased striving, confidence in the future, and a belief that this success would be instrumental to fulfilling other goals—such as providing a secure and happy home for some girl." A few men suggested that John might have a rather dull personality.

"John is thinking about his girl, Cheri, whom he will marry at the end of med school and to whom he can give all the things she desires after he becomes established. He decides that he must not let up but must work even harder than he did before."

Note: In the paper, the male undergrads are described as "men," while the female undergrads are described as "girls." Horner was at Harvard when she wrote this paper. She was the 6th President of Radcliffe College, Harvard's sister college.

Responses about Anne

"65% of the girls were disconcerted, troubled, or confused by the cue. Unusual excellence in women was clearly associated for them with the loss of femininity, social rejection, and person or societal destruction."

"Anne deliberately lowers her academic standing the next term and does all she subtly can to help Carl, whose grades come up. She soon drops out of med-school, they marry, and Carl goes on in school while she raises their family."

"Anne is a code name for a non-existent person created by a group of med students who take turns taking exams and writing papers for Anne."

Anne thinks "maybe she shouldn't have cheated on the exam, then the other men would have felt better about her being stupid."

One especially troubling response

Her husband wants to do as well as she is doing in medical school, but he feels unable to.

Anne will drop out of medical school and go on to law school instead. Her husband will substitute sugar for her contraceptive pills, so she becomes pregnant. She has the baby—in between lectures in law school—and an hour later is back at the books. Her husband hits his head against the wall.

Please note: This response came from a woman!

Better News!

Studies soon showed that the gender-based difference had disappeared!

Adeline Levine and Janice Crumrine, “Women and the Fear of Success: A Problem in Replication,” *American Journal of Sociology* **80**, 964 (1975).

700 students wrote stories in response to “randomly assigned cues concerning success of a male or female medical student.” There were “no significant differences in the percentages of women and men respondents” who included ‘fear of success’ imagery in their stories.

Still, the idea that women might fear success was common in that era.

Gender stereotypes remain in physics laboratory classes

Danny Doucette, Russell Clark, and Chandralekha Singh, “Hermione and the Secretary: How gendered task distribution in introductory physics labs can disrupt equitable learning,” *Eur. J. Phys*. **41**, 035702 (2020).

Hermione archetype: Shouldering a disproportionate amount of the managerial work, while also missing adequate opportunities for experimental work

“I think my partners weren’t always prepared for the labs, so it fell on me to understand and get the group to finish the lab . . . I need to be prepared to know what’s going on, because they won’t.”

Secretary archetype: Recording and analyzing data, missing out on the opportunity to engage fully in the experimental work

“I’m usually in charge of writing down the data that we collect, and my partner is usually the one doing the physical part.”

“He liked to do a lot of the setting up and he knew what was going on, more than I did. I felt like we both tried to split it up, so it wasn’t one person doing all the work. I like to do the data entry and stuff, so often I would do that.”

“On the Practicum, I remember thinking, ‘Dang, my partner always did this part of the lab.’ ”

The Secretary-Tinkerer split: “Students typically thought of it as a fair division of labor.”

Starting my career

The Department of Chemistry at Michigan State University (Michigan Agricultural College, Michigan State College, Michigan State University of Science and Technology) had existed for 124 years without a woman faculty member.

When I was hired, two of the most eminent members of the faculty were categorically opposed to hiring any woman whatsoever, on the grounds that “she would just have children and quit.”

One later apologized. He commented that Professor Emil Fischer, University of Berlin, would not allow women scientists in the lab, for fear that their hair would catch on fire. Lisa Meitner, the co-discoverer of nuclear fission, was allowed to work with Otto Hahn, provided that she promised never to enter the chemistry department.

I did *not* quit when my daughter was born

"It's not the years, it's the mileage," Indiana Jones

First Women Tenure-Stream Faculty Members in Various Chemistry Departments in the US

Wray Huestis	Stanford	1974
Judith Klinman	Berkeley	1978
Veronica Vaida	Harvard	1979
Joan Valentine	UCLA	1980
Sylvia Ceyer	MIT	1981
Frances Arnold	Caltech	1986
Laurie Butler	Chicago	1987
Julie Kovacs	Washington	1988


Kurt Alder
Svante August Arrhenius
Lorenzo Romano Amedeo Carlo Avogadro di Quaregua e di Cerreto
Jöns Jacob Berzelius
Niels Henrik David Bohr
Aleksandr Porfir'evich Borodin
Sir (William) Lawrence Bragg
Eduard Büchner
Robert Wilhelm Bunsen
Arthur Clay Cope
F. (Frank) Albert Cotton
Marie Sklodowska Curie
John Dalton
Sir Humphrey Davy
Peter Debye [Petrus (Pie) Josephus Wilhelmus Debije]
Otto Paul Hermann Diels
Manfred Eigen
Albert Einstein
Gertrude Belle Elion
Michael Faraday
Emil Fischer
Paul John Flory
Rosalind Elsie Franklin
Kenichi Fukui
Josiah Willard Gibbs
Moses Gomberg
(Francois Auguste) Victor Grignard
Dorothy Mary Crowfoot Hodgkin
Roald Hoffmann
Percy Lavon Julian
Isabella Helen Lugoski Karle
Friedrich Auguste Kekulé
John Gamble Kirkwood
Irving Langmuir
Antoine-Laurent Lavoisier
Henri-Louis LeChatelier
Yuan Tseh Lee
Gilbert Newton Lewis
Rudolph Arthur Marcus
Vladimir Vassilyevich Markovnikov
Dmitry Ivanovich Mendeleef
Koji Nakanishi
Louis Pasteur
Linus Carl Pauling
Joseph Priestley
Ilya Prigogine
Sir William Ramsay
Sir Robert Robinson
Otto Rohm and Otto Haas
Barney Rosenberg
Frederick Sanger
Glenn Theodore Seaborg
Howard Ensign Simmons, Jr.
Hermann Staudinger
Gilbert Stork
Andrew Streitwieser, Jr.
Henry Taube
Sir Benjamin Thompson, Count von Rumford
Harold Clayton Urey
Jacobus Hendricus van't Hoff
George M. Whitesides
Friedrich Wöhler
Robert Burns Woodward
Rosalyn Sussman Yalow

The portrait collection of Michigan State University's Department of Chemistry

A total of 133 chemists (66 shown), 6 women, 4.51%

 Marie Curie

 Gertrude Eliason, rational drug design

Rosalind Franklin, X-ray analysis of DNA structure

Isabelle Karle, extraction of plutonium chloride from mixtures

 Dorothy Hodgkin, structure of B-12, penicillin and insulin

 Rosalyn Yalow, radio-immuno assay

The odds for women don't look too good!


Kurt Alder
Svante August Arrhenius
Lorenzo Romano Amedeo Carlo Avogadro di Quaregua e di Cerreto
Jöns Jacob Berzelius
Niels Henrik David Bohr
Aleksandr Porfir'evich Borodin
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Emil Fischer
Paul John Flory
Rosalind Elsie Franklin
Kenichi Fukui
Josiah Willard Gibbs
Moses Gomberg
(Francois Auguste) Victor Grignard
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Antoine-Laurent Lavoisier
Henri-Louis LeChatelier
Yuan Tseh Lee
Gilbert Newton Lewis
Rudolph Arthur Marcus
Vladimir Vassilyevich Markovnikov
Dmitry Ivanovich Mendeleef
Koji Nakanishi
Louis Pasteur
Linus Carl Pauling
Joseph Priestley
Ilya Prigogine
Sir William Ramsay
Sir Robert Robinson
Otto Rohm and Otto Haas
Barney Rosenberg
Frederick Sanger
Glenn Theodore Seaborg
Howard Ensign Simmons, Jr.
Hermann Staudinger
Gilbert Stork
Andrew Streitwieser, Jr.
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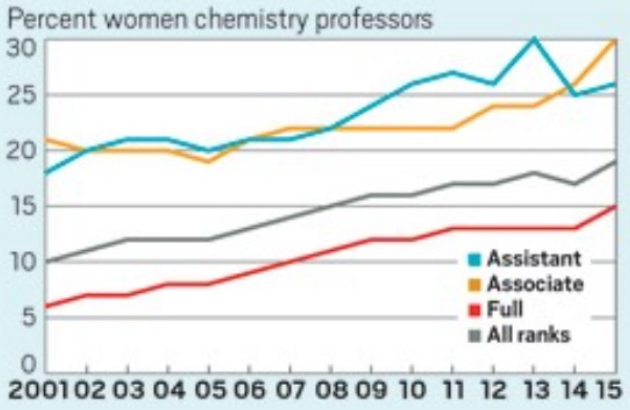
Friedrich Wöhler
Robert Burns Woodward
Rosalyn Sussman Yalow
Jennifer Doudna
Nobel Prize, Chemistry 2020
CRISPR
Emmanuelle Charpentier
Nobel Prize, Chemistry 2020
CRISPR
Carolyn Bertozzi
Nobel Prize, Chemistry 2022
Click Chemistry
Donna Strickland
Nobel Prize, Physics 2018
Compression of Amplified Chirped Pulses
Katelin Karikó
Nobel Prize, Medicine 2023
Messenger RNA
Anne L'Huillier
Nobel Prize, Physics 2023
Attosecond pulses

STEADY CLIMB

ASSISTANT	ASSOCIATE	FULL	ALL
26%	**30%**	**14%**	**19%**
Up **1%** *from prior year*	*Up* **4%** *from prior year*	*Up* **1%** *from prior year*	*Up* **2%** *from prior year*

Top departments for female faculty, 2014–15

	NUMBER OF WOMEN		PERCENTAGE OF WOMEN
Rutgers U, New Brunswick	16	Rutgers U, New Brunswick	33%
Purdue U, West Lafayette	13	Purdue U, West Lafayette	30%
Ohio State U (Columbus)	13	Wayne State U	29%
California, U of, Los Angeles	11	Colorado State U, Fort Collins	28%
Utah, U of	9	Oklahoma, U of (Norman)	27%



Women chemists in academia, 2016–17

Northeastern University had the highest percentage of female chemistry faculty in the most recent OXIDE survey.

	ASSISTANT PROFESSORS			ASSOCIATE PROFESSORS			FULL PROFESSORS			ALL FACULTY		
INSTITUTION	TOTAL	WOMEN	%	TOTAL	WOMEN	%	TOTAL	WOMEN	%	TOTAL	WOMEN	%
Northeastern Univ.	2	1	50%	9	3	33%	11	3	27%	22	7	32%
Purdue Univ., West Lafayette	10	4	40	10	4	40	27	6	22	47	14	30
Univ. of Utah	7	3	43	4	2	50	20	4	20	31	9	29
Univ. of Michigan, Ann Arbor	13	7	54	3	0	0	27	5	19	43	12	28
Univ. of Massachusetts, Amherst	6	3	50	3	2	67	13	1	8	22	6	27
Univ. of California, Los Angeles	5	1	20	7	2	29	35	9	26	47	12	26
Univ. of California, Irvine	7	2	29	9	6	67	36	5	14	52	13	25
Univ. of Illinois, Urbana-Champaign	8	3	38	1	0	0	27	6	22	36	9	25
Harvard Univ.	3	2	67	1	1	100	17	2	12	21	5	24
Univ. of California, Davis	11	4	36	5	2	40	31	5	16	47	11	23
Univ. of Texas, Austin	5	2	40	2	1	50	19	1	5	26	4	15
Emory Univ.	4	2	50	4	1	25	14	0	0	22	3	14
Pennsylvania State Univ., Univ. Park	7	2	29	9	0	0	21	3	14	37	5	14
Univ. of Wisconsin, Madison	2	0	0	5	1	20	28	4	14	35	5	14
Florida State Univ., Tallahassee	6	1	17	7	0	0	19	3	16	32	4	13
Johns Hopkins Univ.	5	2	40	3	1	33	15	0	0	23	3	13
Yale Univ.	6	1	17	0	0	0	19	2	11	25	3	12
Univ. of Chicago	8	0	0	0	0	0	22	3	14	30	3	10
Rice Univ.	0	0	0	6	1	17	16	1	6	22	2	9
Univ. of Southern California	7	1	14	8	0	0	22	2	9	37	3	8
TOTAL	296	79	27%	234	71	30%	1,004	150	15%	1,534	300	20%

A major challenge arises for dual-career couples: The two-body problem

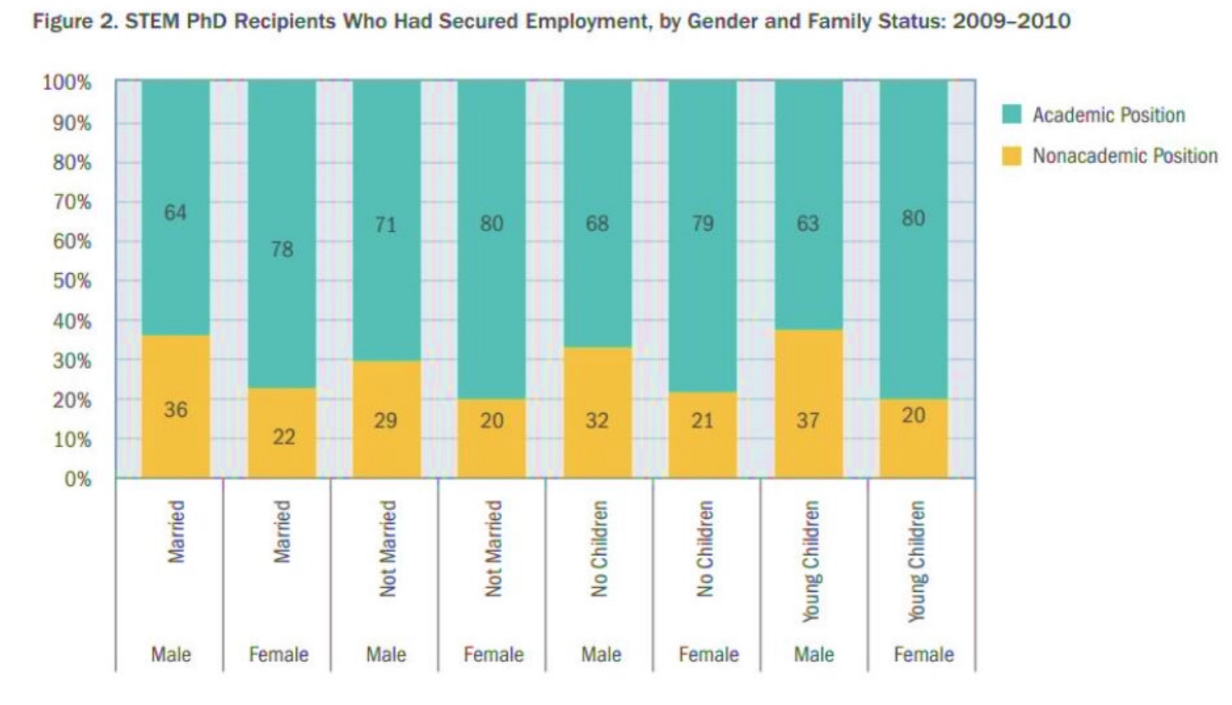
Finding positions that work for both in a couple limits locations and opportunities. The impact tends to be greater on women than on men. Anti-nepotism rules are largely gone now, but challenges remain

59% of female STEM faculty members were married to a male STEM faculty member.

17% of male STEM faculty were married to a female STEM faculty member (Fox, 2005 and Schiebinger *et al*., 2008)

M. F. Fox, Social Studies of Science 35, 131 (2005).
L. Schiebinger, A. D. Henderson, and S. K. Gilmartin, Michelle R. Clayman Institute for Gender Research, Stanford University (2008).

A surprising finding from U.S. News and World Report, March 7, 2014, in an article by Allie Bidwell. Study by Courtney Tanenbaum and Rachel Upton, American Institutes for Research



Challenges for women in science in the US at present?

The increase in the number of women in STEM fields causes some to think there is no longer any problem. Perhaps current numbers reflect actual interest levels? Many younger faculty do not know of the issues that women who were interested in science have faced over time. Quite a few think that there has “always” been affirmative action for women in science. The old challenges still have an influence on the gender distributions in STEM at present.

Sometimes women faculty members in the U.S. serve on more Department committees and counsel more students. Women graduate students may find themselves doing a disproportionate amount of ordering, cleaning, sorting, and organizing.

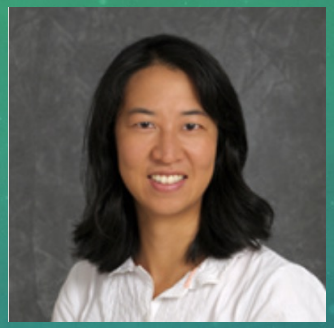
Salary equity?

Graduate class on quantum information theory, this fall at the Freie Universität Berlin

From Jens Eisert on Twitter

But maybe not!

Now on the Chemistry Faculty at Michigan State University

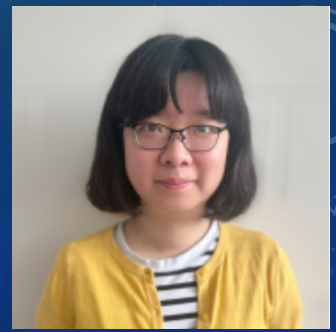








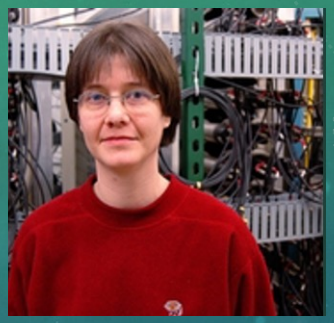




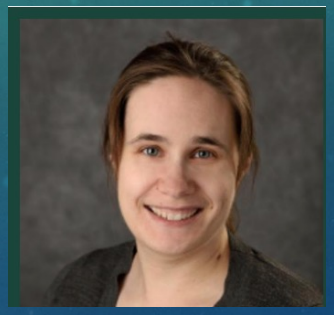
Now on the Physics & Astronomy Faculty at Michigan State University

Also Sophie Berkman and Shuo Zhang











By the Numbers, at Michigan State University

Department of Chemistry			
	Women		Men
Full Professors	4	Full Professors	22
Associate Professors	2	Associate Professors	7
Assistant Professors	8	Assistant Professors	5
~ 29% of the faculty are women, and 18% of the Full Professors are women			
Department of Physics & Astronomy			
	Women		Men
Full Professors	8	Full Professors	39
Associate Professors	3	Associate Professors	13
Assistant Professors	5	Assistant Professors	6
~ 21% of the faculty are women, and 24% of the Full Professors are women			