

Ethics for Young Scientists and Engineers

Celia Mathews Elliott

Department of Physics

University of Illinois



*Each physicist is a citizen of
the community of science.
Each shares responsibility
for the welfare of this
community.*

—Statement by the APS

<http://www.aps.org/statements/02.2.html>

© 2023 The Board of Trustees of the University of Illinois
All rights reserved.

With thanks to David Hertzog, Lance Cooper,
Alan Nathan, and Brian DeMarco, who contributed
ideas and insights



You are now “scientists.”

Science requires its practitioners to be:

Honest—do not fabricate, misrepresent, manipulate, or destroy data.

Careful—apply rigorous standards.

Skeptical—don’t want to believe so much in some result that you lose your objectivity and critical thinking.

Open—share data, methods, theories, equipment; allow others to see your work; be open to criticism.

Generous—give credit to others; do not plagiarize others’ work; help others.

Socially responsible—anticipate the consequences of research; prevent harm to the public and promote social welfare.

Scientific progress depends on ...

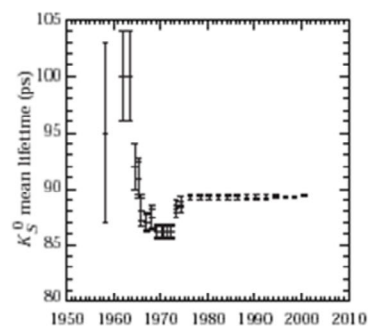
Truthfulness and full disclosure

Accurate and complete record-keeping

**Free and open exchange of data
and interpretations**

Skepticism

***...but honest error
is inevitable***



Experimental measurement of the mean lifetime of the kaon, in ps, from 1950 to 2005.

Science, if it is allowed to function as it should, is self correcting. That's why honesty and openness are essential.

Sometimes there's a thin line between honest error and misconduct, just as there is a line between being bold and being reckless. Ethical issues are often decided "on the margins."

Everyone* recognizes that deliberate dishonesty is wrong

Forged or fabricated data

Falsified or invented results

Plagiarism

Piracy

Hoaxes

***Well, almost everyone...**

J. H. Schön, et al., "Ambipolar Pentacene Field-Effect Transistors and Inverters," *Science* **287**, 1022 (2000).

J. H. Schön, et al., "A Superconducting Field Effect Switch," *Science* **288**, 656 (2000).

In May 2002, a Bell Labs postdoc, Hendrik Schön, was accused of fabricating, manipulating, and destroying data from a number of experiments that had been published in leading scientific journals, including *PRL*, *Science*, and *Nature*. The scandal shook physics to its foundations.

**Physics was rocked to its foundations in 2002
when one of its brightest young stars...**



**MIT
Technology
Review**

**INNOVATORS
UNDER 35**

2002



Jan Hendrik Schön, 31
Nanotechnologies

Lucent Technologies Bell Labs

Hendrik Schön is reinventing the transistor at the place it was born. He and his Bell Labs coworkers have produced single-molecule transistors whose electrical performance is comparable to that of today's best silicon devices but which are hundreds of times smaller.

Making such molecular transistors, which could lead to ultrafast, ultraspeed computers, has been a goal of researchers for years; Schön's clever design established Bell Labs as a leader in the race. But Schön is not interested in simply reinventing the transistor. He wants to change the very materials that form microelectronics, replacing inorganic semiconductors with organic molecules. Schön has made an organic high-temperature superconductor, renewing hopes that superconductors could have widespread electronic applications. He also helped devise the first electrically driven organic laser, which could mean cheaper optoelectronic devices. The soft-spoken Schön recalls being "very surprised" by how well his molecular transistors worked. But it won't be a surprise if Schön helps transform microelectronics.

The Schön case followed shortly after Victor Ninov was fired from LBL for fraud after analysis showed that he had fabricated data used to claim the creation of Element 118, and may have altered original data involved in the discovery of Elements 111 and 112. That Ninov case did not create the widespread consternation that the Schön case did, because it was believed to be the misconduct of one misguided individual. But the Schön episode involved so many co-authors, so many prestigious journals, so many reviewers, and had gone on for so long that it was much more shocking.

**...was accused of fabricating results in
>30 papers, including in *Nature* and *Science***

IOP Physics World - the member magazine of the Institute of Physics

physicsworld.com

Fill

[Home](#) [News](#) [Blog](#) [Multimedia](#) [In depth](#) [Events](#)

News archive

- › 2015
- › 2014
- › 2013
- › 2012
- › 2011
- › 2010
- › 2009
- › 2008
- › 2007
- › 2006
- › 2005
- › 2004
- › 2003
- ~2002
 - › December 2002
 - › November 2002
 - › October 2002
 - › September 2002
 - › August 2002
 - › July 2002

Bell Labs physicist fired for misconduct

Sep 25, 2002

A physicist at Bell Labs has been sacked for falsifying and fabricating data in a series of high-profile papers on superconductivity and molecular electronics. Jan Hendrik Schön was fired today after an investigation committee found him guilty of "scientific misconduct" on 16 out of 24 charges. All of his co-authors, who had contributed to the experiments and appeared on several of the papers, have been cleared of any misconduct.

Schön was first suspected of scientific misconduct earlier this year when physicists noticed similarities between the graphs in two papers published in *Science* and one published in *Nature*. When further suspicious similarities between other papers came to light, the owners of Bell Labs, Lucent Technologies, set up a high-profile committee to investigate if the data had been fabricated. The committee, which was chaired by Malcolm Beasley of Stanford University, questioned Schön as well as his three principal co-authors - Zhenan Bao, Bertram Batlogg and Christian Kloc.

In all, between 31 Oct 2002 and 2 May 2003, *Science* withdrew 9 Schön papers, *PRL* withdrew 6 papers, *Appl. Phys. Lett.* withdrew 4 papers, *Adv. Materials* withdrew 2 papers, and *Nature* withdrew 7 papers. Retraction notices by *Appl. Phys. Lett.* raised concerns about an additional 7 papers by Schön, and *Adv. Materials* issued a retraction notice about an additional Schön paper, in addition to the ones that were formally withdrawn.

After 13 years of rulings, appeals, and new rulings, the German Supreme Court finally revoked Schön’s PhD in 2015


For further reading:
Beasley Report
publish.aps.org/reports/lucentrep.pdf

Plastic Fantastic, E.S. Reich
 (St. Martin’s Griffin, 2010)

The aftermath: In 2004, the University of Konstanz revoked Schön’s PhD based on a state law that allows degrees to be revoked if the degree holder is found to be “unworthy.” Schön sued the university, and in 2010, a court ruled in his favor. The University appealed, and in September 2011, the Administrative Court of Baden–Württemberg in Mannheim ruled that the University was correct in revoking Schön’s degree. The German Federal Administrative Court (equivalent to the US Supreme court) upheld the state court’s decision on 13 July 2015.

For more on the Schön subject:
<http://nanoscale.blogspot.com/2007/01/internet-memory-hole-and-jan-hendrik.html>. Do you agree with Professor Natelson? Does Alcatel-Lucent have any obligation to keep the Beasley Commission Report posted publicly?

Scientific misconduct is drawing increasing federal scrutiny

	NATIONAL SCIENCE FOUNDATION OFFICE OF INSPECTOR GENERAL OFFICE OF INVESTIGATIONS
CLOSEOUT MEMORANDUM	
Case Number: A07100053	Page 1 of 1
<p>We referred allegations of fabrication and falsification of data to a university¹ following our inquiry into the allegations against a former post-doctoral researcher (post-doc)² and his mentor.³ During the period of the alleged misconduct the mentor was a CAREER awardee⁴ and provided acknowledgement to that award in some of the publications involved. The university conducted a full investigation in which it determined that both the post-doc and his mentor had committed research misconduct. The university found that the post-doc had hands-on responsibility for the misconduct. It also found that the mentor, once he had substantial reason to know of the misconduct, continued to use the suspect results to the point of committing research misconduct himself.</p> <p>We concurred with the university investigation and identified additional allegations based on the admissions of both the post-doc and mentor in their interviews, specifically the knowing falsification of the methodology reported in a published article. We recommended NSF make findings of research misconduct (report attached) and recommended debarments. Because of the ongoing risk to federal funds during the adjudication, NSF implemented our recommendation for government-wide suspensions for both pending a final determination.</p> <p>NSF made findings of research misconduct (attached) to which both the post-doc and the mentor appealed. Following the appeals, NSF modified its imposed actions in its final notice of debarment to both (attached).</p> <p>Accordingly, this case is <u>closed</u>.</p>	

Scientific misconduct is drawing increasing federal scrutiny

Case Summaries

This page contains cases in which administrative actions were imposed due to findings of research misconduct. The list only includes those who CURRENTLY have an imposed administrative actions against them. It does NOT include the names of individuals whose administrative actions periods have expired.

2015

- Case Summary: Anderson, David
- Case Summary: Asherin, Ryan
- Case Summary: Bitzegeio, Julia
- Case Summary: Blaylock, Brandi
- Case Summary: Brooks, Tereasa L.
- Case Summary: Fujita, Ryouta
- Case Summary: Kang, Bin
- Case Summary: Littlefield, Peter
- Case Summary: Massé, Julie
- Case Summary: Reddy, Venkata J.
- Case Summary: Xiao, Dong

2014

- Case Summary: Ahvazi, Bijan
- Case Summary: Chen, Li
- Case Summary: Cokoros, Melanie
- Case Summary: Deb, Kaushik
- Case Summary: Dzhurka, Igor
- Case Summary: Freeman, Helen C.
- Case Summary: Fu, Jun
- Case Summary: Patel, Parag
- Case Summary: Suzuki, Maiko
- Case Summary: Takahashi, Takao

Case Summary: Anderson, David

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Office of the Secretary
Findings of Research Misconduct

AGENCY: Office of the Secretary, HHS
ACTION: Notice.

SUMMARY: Notice is hereby given that the Office of Research Integrity (ORI) has taken final action in the following case:

David Anderson, University of Oregon, Eugene: Based on an assessment conducted by the University of Oregon, Eugene (UOE), the Respondent's admission, and analysis conducted by ORI, ORI and UOE found that Mr. David Anderson, Graduate Student, UOE, engaged in research misconduct in research supported by National Institute of Mental Health (NIMH), National Institutes of Health (NIH), grants R01 MH087214 and R01 MH077105.

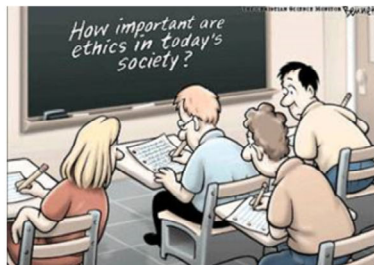
ORI found that Respondent engaged in research misconduct by falsifying and/or fabricating data in the following four (4) publications:

- *Journal of Neuroscience* 31(3):1128-38, 2011 (hereafter referred to as "Paper 1")
- *Journal of Experimental Psychology: Human Perception and Performance* 39(3):824-835, 2012 (hereafter referred to as "Paper 2")
- *Attention, Perception and Psychophysics* 74(5):891-910, 2012 (hereafter referred to as "Paper 3")
- *Psychological Science* 24(6):929-38, 2013 (hereafter referred to as "Paper 4")

ORI found that Respondent knowingly falsified data by removing outlier values or replacing outliers with mean values to produce results that conform to predictions. Specifically, these falsifications appear in:

1. Figures 4 and 8 in Paper 1
2. Figures 3C, 3D, and 3E in Paper 2
3. Figures 3B, 7C, 7D, and 8B in Paper 3
4. Figures 3E and 3F in Paper 4

But, apart from what you learned in kindergarten, what ethics situations might you encounter early in your career?



Using and referencing others' scholarly work
Data selection/rejection and treatment of data
Intellectual property "ownership"; authorship
Human relationships
Impact of research on society

Human relationships—science is a social, collaborative endeavor. Friction and conflicts are inevitable.

**Using others' work:
What must be referenced?**



Using and referencing others' work: Plagiarism is scientific misconduct

Submitting another's published or unpublished work, in whole, in part, or in paraphrase, as one's own without properly crediting the author by footnotes, citations, or bibliographical reference

Submitting material obtained from an individual or agency as one's own original work without reference to the person or agency as the source of the material

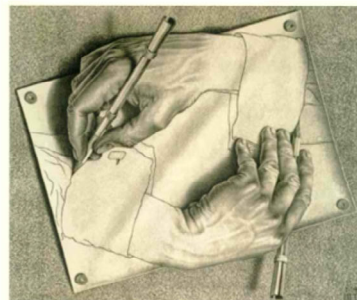
Submitting material that has been produced through unacknowledged collaboration with others as one's own original work without written release from collaborators

It is also scientific career suicide

Credit should always be given for others' work—in references, acknowledgments, and authorship.

At first, it seems straightforward, but sometimes the lines are hard to draw

Using another author's ideas or words without proper documentation; representing someone else's creative work (ideas, words, images, etc.) as one's own, *whether intentional or not.*



M. C. Escher, *Drawing Hands*, 1948

Now, let's look at a real example...

Plagiarism: Case Study*

While classical melting in two-dimensional systems is reminiscent of the phase behavior observed as a function of pressure in this material, an important qualification should be made with respect to this comparison. In contrast to the examples described above, the melting process observed in $1T$ -TiSe₂ is quantum mechanical in nature, in that it is driven near $T = 0$ K by pressure tuning the competing interactions in this system. To understand the nature of this competition, note first that the zero-pressure charge density wave (CDW) state in $1T$ -TiSe₂ is unconventional, as it arises from an indirect Jahn-Teller interaction that splits and lowers the unoccupied conduction band. As a result of the electron-hole interaction between the conduction and valence bands, the lowering of the split conduction band “repulses” and flattens the valence band, resulting in a lowering of the system’s energy, and the formation of a small gap CDW state.

From: C.S. Snow et al., Phys. Rev. Lett. 91, 136402 (2003)

*S.L. Cooper, PHYS 496, 2008.

Original:

While classical melting in two-dimensional systems is reminiscent of the phase behavior observed as a function of pressure in this material, an important qualification should be made with respect to this comparison.

In contrast to the examples described above, the melting process observed in $1T\text{-TiSe}_2$ is quantum mechanical in nature, in that it is driven near $T = 0$ K by pressure tuning the competing interactions in this system.

To understand the nature of this competition, note first that the zero-pressure charge density wave (CDW) state in $1T\text{-TiSe}_2$ is unconventional, as it arises from an indirect Jahn–Teller interaction that splits and lowers the unoccupied conduction band.

As a result of the electron-hole interaction between the conduction and valence bands, the lowering of the split conduction band “repulses” and flattens the valence band, resulting in a lowering of the system’s energy, and the formation of a small gap CDW state.

My version:

The phase behavior observed as a function of pressure in $1T\text{-TiSe}_2$ is similar to classical melting in 2D materials.

However, in contrast to classical melting, the melting process seen in $1T\text{-TiSe}_2$ is governed by quantum mechanics, as it the result of tuning the competing quantum mechanical interactions with pressure near $T = 0$ K.

An examination of the unconventional charge density wave (CDW) in $1T\text{-TiSe}_2$ state helps elucidate this competition—the CDW state in $1T\text{-TiSe}_2$ is caused by an indirect Jahn–Teller interaction that lowers the unoccupied conduction band relative to the filled valence band.

Because there is a strong electron-hole interaction between the conduction and valence bands in this material, this lowering of the conduction band causes a “repulsion” and flattening of the valence band, which results in a lowering of the system’s energy and the formation of a small CDW small gap.

Is it plagiarism?

Tips for avoiding plagiarism:

Study the original text until you *fully* understand its meaning

Set aside the original and write a summary of the text *in your own words*; label it so you know it's *your* words

Check your version with the original to ensure that the meaning has been retained

Enclose any text or phrase that you have reproduced exactly in quotation marks

Cite the source!

What has to be cited?

“...as first shown by Newton, $F = ma$.”¹ 

Exception for “common knowledge”

BUT

“common knowledge” is context dependent

field and subfield

audience

venue

Should it be cited? Err on the side of generosity!

(particularly if the author is still alive...)

¹Isaac Newton, *Philosophiae Naturalis Principia Mathematica* (London, 1687).

When to cite?

Is the fact readily available from numerous sources (textbooks) and generally known to the public? (no citation needed)

Is the idea or fact a result of unique individual research? (must cite)

If I change the words, do I still have to cite the source? **YES!**

Which source should be cited?

**Cite original, not derivative work, if possible—
minimizes risk of misinterpretation or error in
the secondary source**

**Cite the final, peer-reviewed, published version,
not the preprint (*Phys. Rev. D*, not arXiv)**

Bad citation practices:**Selective citation—incomplete, biased****Citing inaccessible sources****Citing papers you haven't actually read (!)****Misrepresenting the cited paper****Citing indiscriminately (the “core dump”)**

“Literature references should not be tacked onto a manuscript
...instead, they need to be used with taste and judgment.

Although some may consider references mere “window
dressing”—something added to a manuscript to make it look
scholarly—their misuse speaks loudly for itself...Such citations
become annoying rather than illuminating.”

—Herbert B. Michaelson

How to Write & Publish Engineering Papers and Reports

**Data selection:
What if you have “bad” data?**



Although data falsification or fabrication is clearly wrong, what about more-subtle data “selection”?

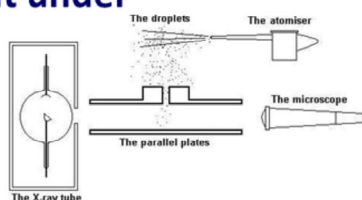
Example: In 1909, Millikan measured the charge e of the electron in his famous “oil drop” experiment ... there have been raging scholarly debates since then about his use of “selected” drops, given his claim that *all* drops were included in his published results

- Too bad there remains a kind of doubt hanging over it
- An important and highly scrutinized result (Nobel Prize),
- We won't debate that here, but you can read about it <http://www.its.caltech.edu/~dg/MillikanII.pdf>



In science, it is generally accepted that certain data may be rejected, but under what conditions?

Reality of the experimental method
—things go wrong; equipment malfunctions, and people make mistakes



Manipulation or enhancement of images is becoming is huge issue

From the Council of Science Editors*:

- 1. No specific feature within an image may be enhanced, obscured, moved, removed, or introduced**
- 2. Adjustments of brightness, contrast, or color balance are acceptable if they are applied to the whole image and do not obscure, eliminate, or misrepresent any data present in the original**
- 3. The grouping of images from different parts of the same image or from different images must be made explicit**
- 4. If the author cannot produce the original data, acceptance of the manuscript should be revoked**

*<http://www.councilscienceeditors.org/resource-library/editorial-policies/white-paper-on-publication-ethics/3-4-digital-images-and-misconduct/>

Data may be excluded or manipulated but must be disclosed

Use accepted statistical tests §

**Decide before the experiment what criteria will be
used to accept or exclude data**

**More difficult ... after the experiment you discover
biases based on something you monitored but you
did not “pre-reject” data. Now what?**

**If images are enhanced, you must do the same to
everything in the image; no selective enhancement**

§ J.R. Taylor, *An Introduction to Error Analysis* (Mill Valley CA,
University Science Books, 1982).

Data selection or treatment is okay,

- 1) as long as it is disclosed.
- 2) as long as the original data are kept permanently and made available to other researchers.

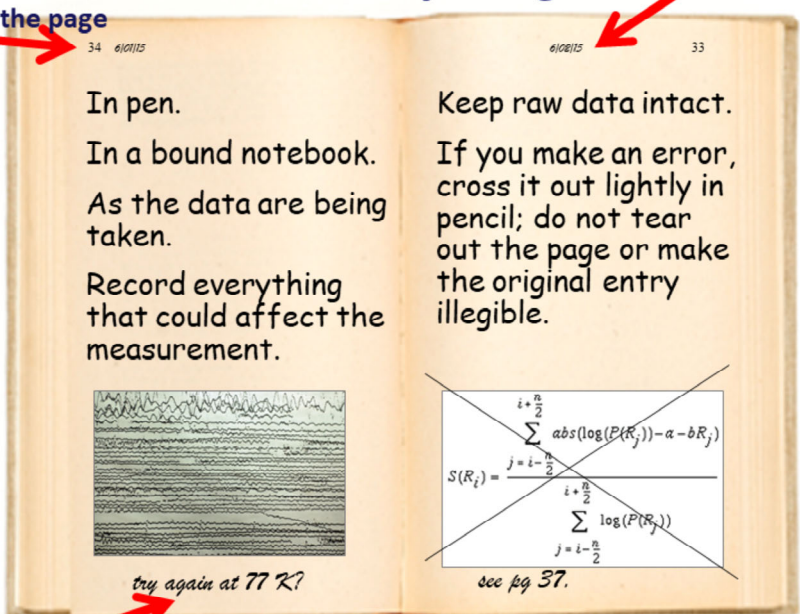
Ideally, decide **before** you do the experiment what your criteria are for rejecting data, so any data selection is results-neutral.

Solution: Record everything!

Number the page → 34 6/10/15

Date every entry → 6/10/15 33

In pen.
In a bound notebook.
As the data are being taken.
Record everything that could affect the measurement.



try again at 77 K?

Keep raw data intact.
If you make an error, cross it out lightly in pencil; do not tear out the page or make the original entry illegible.

$$S(R_i) = \frac{\sum_{j=i-\frac{n}{2}}^{i+\frac{n}{2}} \text{abs}(\log(P(R_j)) - \alpha - bR_j)}{\sum_{j=i-\frac{n}{2}}^{i+\frac{n}{2}} \log(P(R_j))}$$

see pg 37.

Write notes to yourself so you have a record of when you had the idea

Research results should be recorded and permanently maintained to allow for analysis and review.

Data should be immediately available to supervisors and collaborators.

After publication, original data records must be maintained completely and made available to other scientists.

Collaborations must have a mechanism to respond to questions about the joint work and share information with other scientists.

Falsification or fabrication of data is an egregious breach of ethical conduct.

Selective reporting of data with the intent to mislead or deceive is an egregious breach of ethical conduct.



NOT you—your employer owns all data produced during your employment

At universities, the university owns all research data

Your notebooks are the property of the lab

You may not disseminate data in *any* way without your supervisor's permission

The “principal investigator” (PI) is responsible to the agency who funded the work for the proper acquisition, recording, analysis, protection, management, curation, preservation, and sharing of all data arising from the funded research

**Authorship:
Who gets to be an author?
What about priority in the author list?**



Conflicts can arise over authorship

Authorship should be limited to those who contributed *meaningfully* to the concept, design, execution, or analysis of the work

- ✓ Each person who contributed to the work should be offered authorship
- ✓ Every co-author should have an opportunity to examine a manuscript prior to publication
- ✓ Each author is obligated to promptly disclose errors and provide corrections for published work
- ✓ Other contributors should be acknowledged
- ✓ Credit should always be given for others' work

Who decides?

**The leader of the research group (professor)
In large collaborations, a committee**

**As a student, you may not “publish” anything
without your research adviser’s *explicit*
permission**

- ✓ Journal articles
- ✓ Posters
- ✓ Talks
- ✓ Interviews
- ✓ Social media

Coauthors and collaborators share responsibility for published work

Some coauthors are responsible for accuracy and verifiability of the *entire paper*

Built the apparatus, recorded the data, analyzed the data, supervised junior researchers, wrote the paper

Coauthors who make specific, limited contributions may have only limited responsibility

Fabricated the thin films that others tested

All collaborations should have a process for reviewing and ensuring the accuracy and validity of reported results

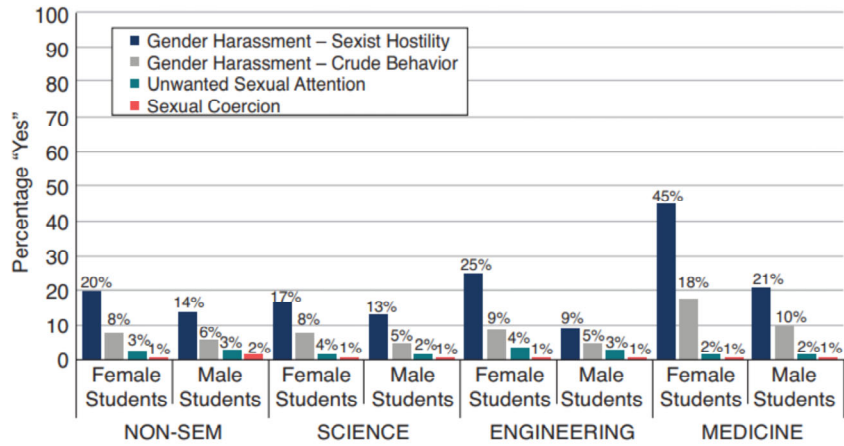
Anyone unwilling or unable to accept appropriate responsibility for a paper should not be a coauthor

**Interpersonal relationships:
What are your rights and obligations?**



Sexual harassment—it's still happening

Marcy (Berkeley), Ott (Caltech),
Slater (Arizona/Wyoming), Lieb (Chicago) ...



National Academies of Sciences, Engineering, and Medicine. 2018. Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine. Washington, DC: The National Academies Press., p. 60. <https://doi.org/10.17226/24994>.

Title IX: Education Amendments (1972)

“Title IX of the Education Amendments of 1972 (“Title IX”), 20 U.S.C. §1681 et seq., is a Federal civil rights law that prohibits discrimination on the basis of sex in education programs and activities. All public and private elementary and secondary schools, school districts, colleges, and universities (hereinafter “schools”) receiving any Federal funds must comply with Title IX. Under Title IX, discrimination on the basis of sex can include sexual harassment or sexual violence, such as rape, sexual assault, sexual battery, and sexual coercion.”

http://studentcode.illinois.edu/article1_part1_1-111.html

Note: professors and staff are “required reporters”

Be aware of your *other* ethical responsibilities as a scientist



Don't claim expertise or credentials you don't have*

Be proactive about avoiding conflicts of interest or commitment

Always disclose funding

Promote openness and collegiality

Treat colleagues and subordinates with respect

***William Shockley and "dysgenics"**

<https://www.youtube.com/watch?v=UaoEWR2ndvA>

Being an ethical scientist goes beyond "don't cheat" and "don't make things up."

Represent yourself as an expert only in your field of competence and only to the extent that your formal qualifications, credentials, and relevant experience allow.

A variety of activities and relationships in science may lead to conflicts

- Financial support of research

- Adviser/student, collegial, and collaborative relationships

- Competitive relationships

Always disclose sources of funding

Science is a social, collaborative effort; it's not all about YOU.

Every scientist has an ethical obligation to disclose scientific misconduct.

That said, you also have an obligation to promote a supportive, collegial, cooperative environment. Don't make an accusation until you have all the facts and have considered all options. Talk the situation over with someone you trust and who can give you objective advice.

To recap:

Science ethics rest on six fundamental principles—honesty, carefulness, objectivity, openness, giving credit, social responsibility

Science is a human endeavor, and ethical issues are likely to arise over your career

Use your own personal ethical values to inform your behavior

Ask for help if you need it—you are not alone

Your reputation is your most valuable scientific asset—protect it



cmelliot@illinois.edu

<http://physics.illinois.edu/people/Celia>