

The background of the slide is a photograph of a university campus. In the center, there is a large, multi-story brick building with a prominent square tower featuring a pointed roof and a small cupola. The building is surrounded by lush green trees with some autumn-colored leaves. A paved walkway leads towards the building from the foreground. The overall scene is bright and clear.

***Responsible Conduct of Research
Workshop Series, 2017-2018***

**Misconduct in Research & Creative
Activities**

--February 8, 2018--

James Pivarnik



- Research Integrity Officer
 - ▣ Professor of Kinesiology & Epidemiology

What Every Student Should Know About Research Misconduct

James M. Pivarnik, PhD
Research Integrity Officer (RIO)
Michigan State University

www.rio.msu.edu

RIO@msu.edu

107 Olds Hall

517-432-6698



Character is doing the right thing when nobody's looking. There are too many people who think that the only thing that's right is to get by, and the only thing that's wrong is to get caught.

(J. C. Watts)

izquotes.com

A few recent research misconduct cases



Marc Hauser



- Studied cognitive evolution in primates
- Found guilty of 8 counts of research misconduct in 2010
- Harvard placed him on administrative leave, he later resigned

Dipak K Das



- Studied resveratrol
- Found guilty by UCONN of 145 instances of Research Misconduct
- Case began as an anonymous tip in 2008

Dong-Pyou Han



- HIV/AIDS researcher
- Added human HIV antibodies to rabbit blood
- The scam went on for years, the investigator resigned from IA State in Oct, 2013
- Sentenced to 57 months in prison

The Poehlman case: running away from the truth*

John E. Dahlberg[†] and Christian C. Mahler[‡]

[†]U.S. Department of Health & Human Services, Office of Research Integrity

[‡]U.S. Department of Health & Human Services, Office of the General Counsel

Keywords: scientific misconduct, lifetime debarment, criminal fraud, gerontology research, menopause transition

ABSTRACT: *Eric T. Poehlman, Ph.D., was an internationally recognized, tenured professor at the University of Vermont (UVM) in Burlington when, in October 2000, a junior member of Poehlman's laboratory became convinced that he had altered data from a study on aging volunteers from the Burlington area. This suspicion developed into one of the most significant cases of scientific misconduct in the history of the US Department of Health and Human Services' (HHS) Office of Research Integrity (ORI), launching a US Department of Justice (DOJ) civil and criminal fraud investigation and, eventually, to a much publicized guilty plea and felony conviction. In the end, Dr. Poehlman admitted to 54 findings of scientific misconduct made by the UVM and ORI, agreed to retract or correct ten of his publications and to exclude himself from federal procurement and nonprocurement transactions for life. The United States Government's handling of this case was distinguished by a highly cooperative approach that integrated the resources of the US Attorney's Office for the District of Vermont (USAO) and both ORI and the Office of the Inspector General (OIG) in HHS in the common goal of prosecuting research fraud.*

* The content of this article represents the personal views of the authors and does not express the opinion or policy of DHHS or its components.

A paper on this topic was presented at the 6th International Bioethics Conference on the subject of 'The Responsible Conduct of Basic and Clinical Research', held in Warsaw, Poland, 3-4 June 2005.

Addresses for correspondence:

John E. Dahlberg, Ph.D., Senior Investigator, Division of Investigative Oversight, Office of Research Integrity, U.S. Department of Health & Human Services, Tower Oaks Bldg., Suite 750, Rockville, Maryland 20852, USA; email: jdahlberg@osophs.dhhs.gov.

Christian C. Mahler, J.D., Senior Attorney, Office of the General Counsel, Public Health Division, U.S. Department of Health & Human Services, 5600 Fishers Lane, Suite 4A-53, Parklawn Bldg., Rockville, Maryland 20857, USA; email: cmahler@psc.gov.

1353-3452: 2006. Published by Opragen Publications, <http://www.opragen.co.uk>.





MARYLAND TECHNOLOGY ENTERPRISE INSTITUTE **LEARN. LAUNCH. FLY.**

PATHS FOR MARYLAND ENTREPRENEUR & INNOVATORS



Concussion-Related Measures Improved in High School Football Players Who Drank New Chocolate Milk, UMD Study Shows

UPDATE: This press release refers to study results that are preliminary and have not been subjected to the peer review scientific process.

COLLEGE PARK, Md. — **Fifth Quarter Fresh**, a new, high-protein chocolate milk, helped high school football players improve their cognitive and motor function over the course of a season, even after experiencing concussions, a new preliminary University of Maryland study shows.

The study, funded through the **Maryland Industrial Partnerships program** and conducted by **Jae Kun Shim**, a professor of kinesiology in the **School of Public Health**, followed 474 football players from seven high schools in Western Maryland throughout the fall 2014 season.

"High school football players, regardless of concussions, who drank Fifth Quarter Fresh chocolate milk during the season, showed positive results overall," said Shim. "Athletes who drank the milk, compared to those who did not, scored higher after the season than before it started, specifically in the areas of verbal and visual memory."

Football players were tested before the season, after concussions and post-season



Download high-quality Fifth Quarter Fresh videos, photos and logos (including those shown below) via [Mtech's public Dropbox folder](#).



Fifth Quarter Fresh bottle



JANUARY 11, 2016

Share Tweet

Why won't the University of Maryland talk about the chocolate milk/concussion study it was so eager to promote?

POSTED BY



CATEGORIES

Health care journalism, News releases

TAGS

chocolate milk, concussions, University of Maryland

Editor's note: In response to concerns first raised by HealthNewsReview.org in a news release review and the following blog post, the University of Maryland has announced it is conducting an investigation into the study at the center of this controversy.

Why did the University of Maryland issue multiple news releases about a health research project... and then decline to talk about it? That's just one of the questions piling up about research involving high school football players, concussions and a brand of chocolate milk.



It started routinely. I was asked by HealthNewsReview.org to take the first look at a news release from the University of Maryland. "Concussion-Related Measures Improved in High School Football Players Who Drank New Chocolate Milk, UMD Study Shows" read the headline. The lead went further, claiming not just an association, but that the milk was responsible.

BAD SCIENCE

The University of Maryland Has a Burgeoning Chocolate-Milk Concussion Scandal on Its Hands

By Jesse Singal Follow @jessesingal

January 20, 2016 1:03 p.m.

1.5k Shares

- Share 1.2k
- Tweet 363
- Share 9
- Share 9
- Email
- Print

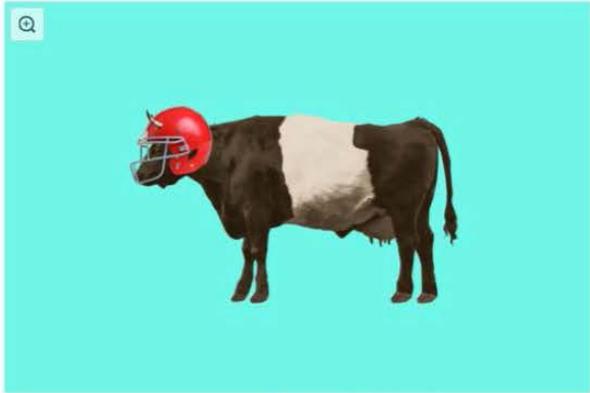


Photo-illustration: Photo: Patrick Klok/Creative Commons

On December 22, the University of Maryland published a remarkable press release about some research it had conducted. According to the release, a study conducted by a professor at the UMD School of Public Health had shown that a product called Fifth Quarter Fresh — basically, a fancy, fortified chocolate milk — “helped high school football players improve their cognitive and motor function over the course of a season, even after experiencing concussions.”

Given the current focus on youth concussions, it's no surprise that this news traveled fast and that the claim appears to have benefited the company in question. Motivated by what appeared to be sturdy scientific

Wakefield's article linking MMR vaccine and autism was fraudulent

Clear evidence of falsification of data should now close the door on this damaging vaccine scare

FEATURE, p 77

Fiona Godlee editor in chief, *BMJ*, London, UK
fgodlee@bmj.com

Jane Smith deputy editor, *BMJ*, London, UK

Harvey Marcovitch associate editor, *BMJ*, London, UK

Cite this as: *BMJ* ; :c
doi:10.1136/bmj.c7452

"Science is at once the most questioning and . . . sceptical of activities and also the most trusting," said Arnold Relman, former editor of the *New England Journal of Medicine*, in 1989. "It is intensely sceptical about the possibility of error, but totally trusting about the possibility of fraud."¹ Never has this been truer than of the 1998 *Lancet* paper that implied a link between the measles, mumps, and rubella (MMR) vaccine and a "new syndrome" of autism and bowel disease.

Authored by Andrew Wakefield and 12 others, the paper's scientific limitations were clear when it appeared in 1998.^{2,3} As the ensuing vaccine scare took off, critics quickly pointed out that the paper was a small case series with no controls, linked three common conditions, and

relied on parental recall and beliefs.⁴ Over the following decade, epidemiological studies consistently found no evidence of a link between the MMR vaccine and autism.⁵⁻⁸ By the time the paper was finally retracted 12 years later,⁹ after forensic dissection at the General Medical Council's (GMC) longest ever fitness to practise hearing,¹⁰ few people could deny that it was fatally flawed both scientifically and ethically. But it has taken the diligent scepticism of one man, standing outside medicine and science, to show that the paper was in fact an elaborate fraud.

In a series of articles starting this week, and seven years after first looking into the MMR scare, journalist Brian Deer now shows the extent of Wakefield's fraud and how it was perpetrated. Drawing on interviews, documents, and data

Office of Research Integrity



THE LAB

Avoiding Research Misconduct

Interactive Movie on Research Misconduct
Watch Full Version Online

The graphic features the title 'THE LAB' in large, hand-drawn, textured letters. Below it, the subtitle 'Avoiding Research Misconduct' is written in a clean, sans-serif font. At the bottom left, there is a play button icon followed by the text 'Interactive Movie on Research Misconduct' and 'Watch Full Version Online'. On the right side, four diverse individuals (two men and two women) are shown from the chest up, standing in a row with their arms crossed, looking directly at the camera. The background is a light-colored grid pattern.

What the RIO does

- The RIO is responsible for seeing to it that the MSU Procedures Concerning Allegations of Misconduct in Research and Creative Activities are carried out in an unbiased, confidential, and professional manner.
- Required for any institution seeking and accepting federal funding (42 CFR 93)

- Funding
- Collaboration
- Compliance
- Commercialization
- Policies
- Resources
- Events & Training
- Units

Home

About

Authorship

Sample Agreement

Federal Agencies

Research Misconduct Procdures (PDF)

Research Data

Resources

Contact Us

Research Integrity Officer

The Research Integrity Officer (RIO) receives and manages Allegations of Misconduct in Research within the MSU community. Research Misconduct includes Plagiarism, Fabrication, Falsification, and other research activities that seriously deviate from accepted practices in the research community.

The Michigan State University policy can be found in the [Procedures Concerning Allegations of Misconduct in Research and Creative Activities](#).

The RIO also manages authorship and data disputes according to MSU's Authorship and Research Data: Management, Control, and Access guidelines. In this role, the RIO provides advice to administrators, faculty and students in best authorship and data management practices.

Please feel free to contact us if you have questions/concerns about any research integrity matter. Our discussions can remain confidential.



James M. Pivarnik, Ph.D.
Research Integrity Officer
107 Olds Hall
408 W. Circle Drive
East Lansing, Michigan 48824
Phone: (517) 432-6698
Email: rio@msu.edu

Search

Announcements

MSU bloggers post on 'Spartan Ideas'
Spartan Ideas is an MSU website maintained by MSU Libraries and the Office of the Vice President for Research and Graduate Studies. It is designed to showcase a continuously growing selection of MSU's faculty, student, and staff blogs. A team of MSU librarians "curates" this collection, choosing...[more](#)

1 2

PROCEDURES CONCERNING
ALLEGATIONS OF MISCONDUCT IN
RESEARCH AND CREATIVE
ACTIVITIES

19 June 2009

The role of the RIO

- The RIO shall coordinate implementation of these Procedures and shall be responsible for their fair and impartial administration. **The RIO shall not be an advocate for the Complainant or the Respondent.**

Question

- Is the RIO the most thankless job at Michigan State University?
- Yes

Question

- Is the RIO the most despised entity at Michigan State University?
- No

So who is?



What exactly is “Research Misconduct”?



Research Misconduct

(Michigan State)

Fabrication, Falsification, Plagiarism, or any other practice, that **Seriously Deviates** from practices commonly accepted in the discipline or in the academic and research communities generally in proposing, performing, reviewing, or reporting Research and Creative Activities. **Misconduct does not include appropriative practices in the Creative Arts insofar as they accord with accepted standards in the relevant discipline.** Misconduct does not include honest error or honest differences in the interpretation or judgment of Research data.

It doesn't
matter what I
think, the
evidence says
everything

Mac Taylor, CSI New York



How does the process begin?



Misconduct Process

- Allegation
 - Complainant(s)
 - Respondent(s)

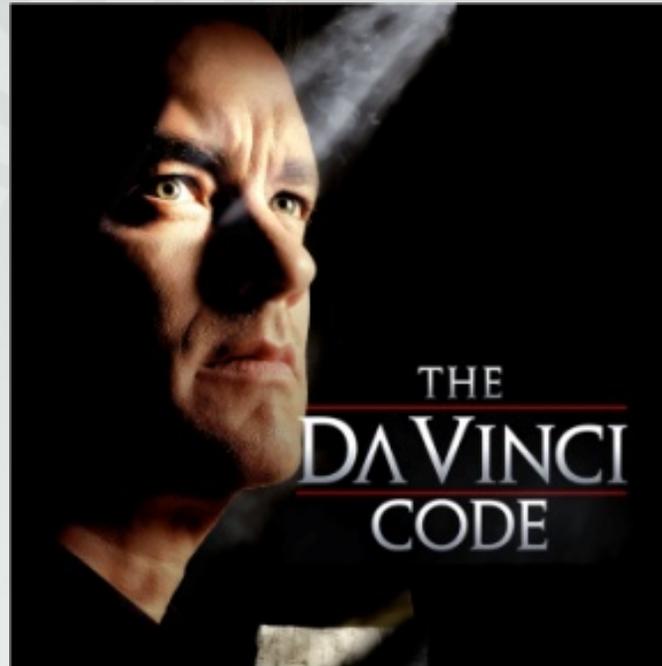
- Preliminary Assessment (by me)
 - Meet definition?
 - Any evidence?

My most important phrase



My most important phrase

- “it could be”



Misconduct Process

- Allegation
 - Complainant(s)
 - Respondent(s)
- Preliminary Assessment (by me)
- Inquiry Panel
- Investigative Committee

- Exoneration or Finding

Fabrication

- Fabrication is making up data or results and recording or reporting them.

Falsification

- Falsification is manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

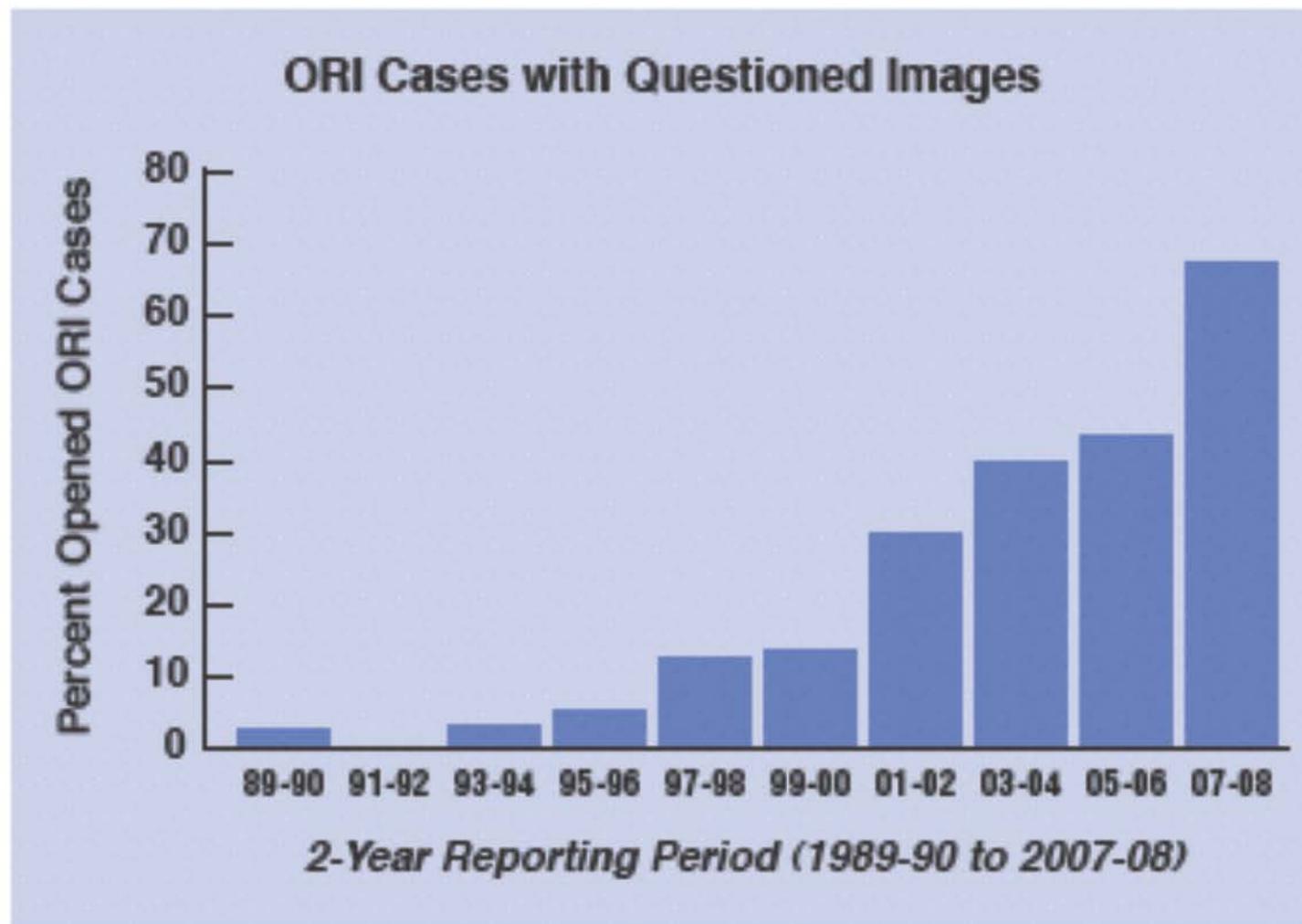


Figure 1: Cases formally opened by ORI that involve questioned images

Plagiarism

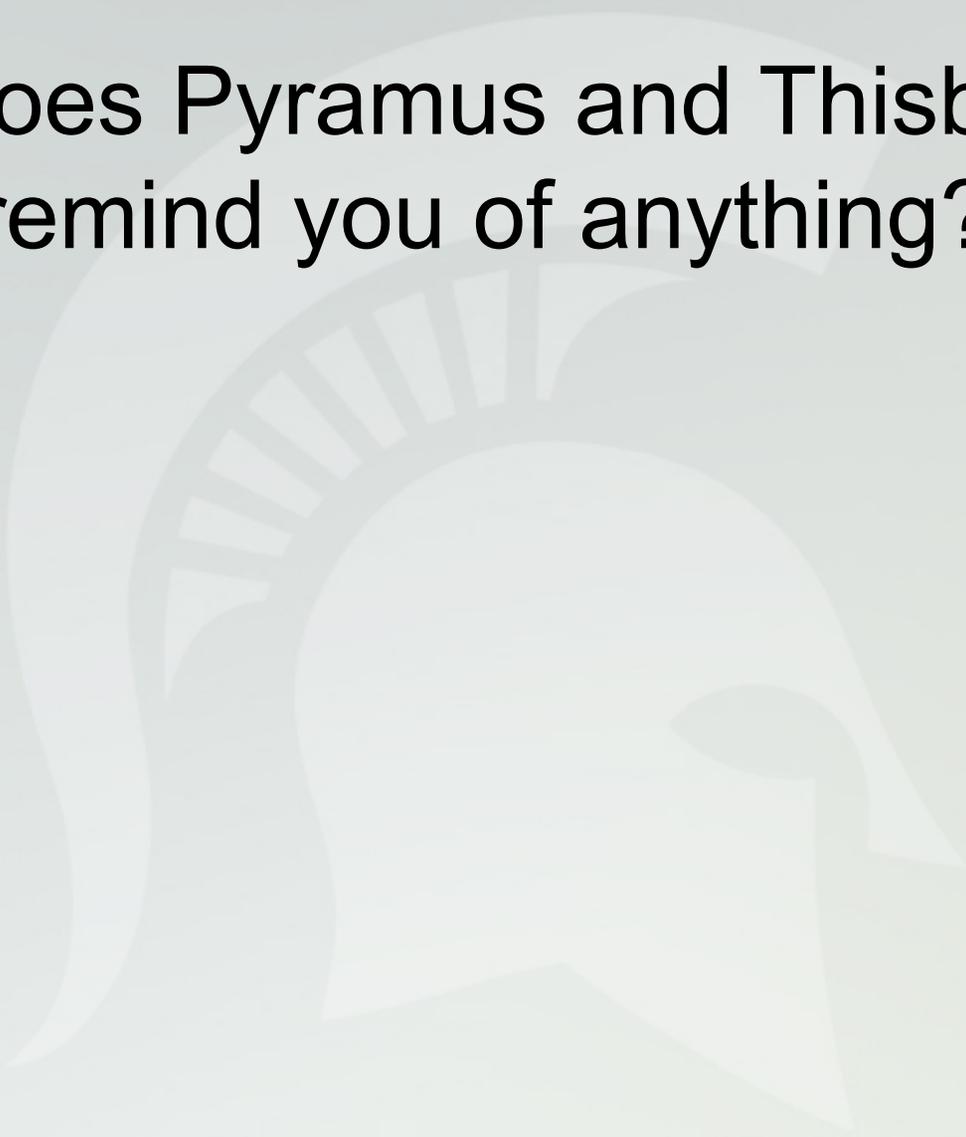
- Plagiarism is appropriation of another person's ideas, processes, results, or words without giving appropriate credit.

- **Pyramus and Thisbe**, in classical mythology, youth and maiden of Babylon, whose parents opposed their marriage. Their homes adjoined, and they conversed through a crevice in the dividing wall. On a night when they had arranged to meet at the tomb of Ninus, Thisbe, who was the first at the trysting place, was frightened by a lion with jaws bloody from its prey. As she fled, she dropped her mantle, which was seized by the lion. When Pyramus came, the torn and bloody mantle convinced him that she had been slain. He killed himself, and Thisbe, returning, took her own life with his sword. The white fruit of a mulberry tree that stood at the trysting place was dyed red with Pyramus' blood, and the fruit was ever after the color of blood.

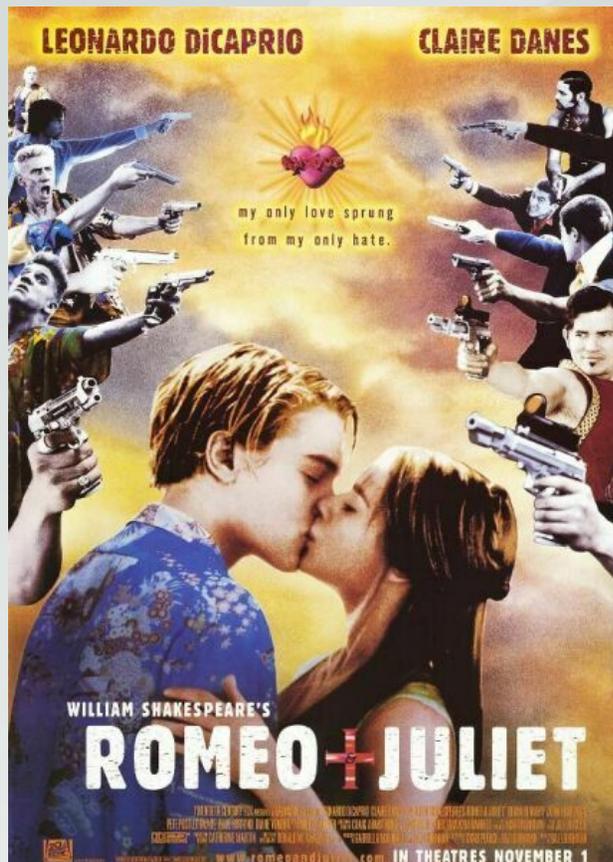


- Written by Ovid
- Between 5-3 BC

Does Pyramus and Thisbe
remind you of anything?

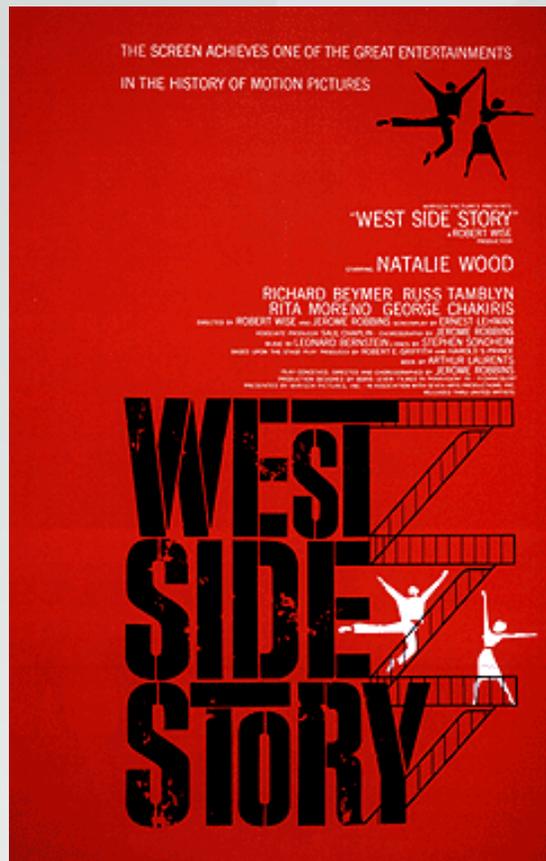


Does Pyramus and Thisbe remind you of anything?



- William Shakespeare
- 1595

Does Pyramus and Thisbe remind you of anything?



- Arthur Laurents
- 1957

- Accusations of plagiarism should be judged individually, taking into account the actual damage done to the original author and current copyright holder, and whether or not the alleged theft actually has any artistic merits in its own right.
- Feb 27, 2007
- thunderpeel2001.blogspot.com
- Posted by Johnny Walker

- A judgment of plagiarism requires that the copying, besides being deceitful in the sense of misleading the intended readers, induces **reliance** by them. By this I mean that the reader does something because he thinks the plagiarizing work original that he would not have done had he known the truth.
- Richard A. Posner
- The Little Book of Plagiarism (Pantheon Books, NY), 2007
- Page 19

Founded in 1954

AMERICAN COLLEGE of SPORTS MEDICINE

Mission Statement: The American College of Sports Medicine advances and integrates scientific research to provide educational and practical applications of exercise science and sports medicine.

September 11, 2009

President Barack Obama
The White House
Washington, DC 20500

Dear Mr. President:

On behalf of the more than 35,000 members and certified professionals of the American College of Sports Medicine (ACSM), I am writing to thank you for highlighting the importance of covering routine checkups and preventive care, like mammograms and colonoscopies, in your speech on Wednesday, Sept. 9, 2009, before a joint session of Congress.

However, we believe that prevention and wellness is much more than just clinical preventive services and should include initiatives designed to encourage healthy lifestyles, including increasing physical activity and improving nutrition. As you know, five of the costliest illnesses and conditions – cancer, cardiovascular disease, diabetes, lung disease, and strokes – can be prevented through a combination of healthy lifestyles and essential screenings.

ACSM is the largest sports medicine and exercise science organization in the world. Its members have applied their knowledge, training, and dedication in sports medicine and exercise science to promote healthier lifestyles for people around the globe. In addition to improving the health of citizens worldwide, our members' research has also proven that fitness increases worker productivity and job performance.

You may be interested to know that for more than two years ACSM has been spearheading an innovative program to prevent illness and disease. The Exercise is Medicine™ program, launched in conjunction with the American Medical Association, is designed to encourage America's patients to incorporate physical activity and exercise into their daily routine. Exercise is Medicine™ specifically calls on doctors to prescribe exercise to their patients, which is the kind of initiative that will help you achieve your goal of stepping up efforts to advance the cause of healthy living.

We thank you once again for your commitment to providing leadership on this issue and we look forward to working with you to ensure that healthy lifestyles, including increased physical activity and better nutrition play a much more prominent role in the future than it has in the past.

Sincerely,

James M. Pivarnik, FACSM
President
American College of Sports Medicine

CC:
Nancy-Ann DeParle, White House Office of Health Reform
Kathleen Sebelius, HHS Secretary

James M. Pivarnik, Ph.D., FACSM
President
Departments of Kinesiology and Epidemiology
Michigan State University
East Lansing, Michigan

Thomas M. Best, M.D., Ph.D., FACSM
President-elect
The OSU Sports Medicine Center
The Ohio State University
Columbus, Ohio

Melinda Millard-Stafford, Ph.D., FACSM
Immediate Past President
School of Applied Physiology
Georgia Institute of Technology
Atlanta, Georgia

Janice L. Thompson, FACSM
First Vice President
Department of Exercise, Nutrition and Health Sciences
The University of Bristol
Bristol, UNITED KINGDOM

Gregory W. Heath, DHS, MPH, FACSM
First Vice President
Department of Health and Human Performance
University of Tennessee at Chattanooga
Chattanooga, Tennessee

Melinda M. Manore, Ph.D., R.D., FACSM
Second Vice President
Department of Nutritional and Exercise Science
College of Health and Human Sciences
Oregon State University
Corvallis, Oregon

David C. Nieman, D.Ph., FACSM
Second Vice President
Human Performance Laboratory
Appalachian State University
Boone, North Carolina

J. Larry Durstine, Ph.D., FACSM
Treasurer
Department of Exercise Science
University of South Carolina
Columbia, South Carolina

James R. Whitehead
Executive Vice President
ACSM National Center
Indianapolis, Indiana

Advanced Team Physician Course
December 3-6, 2009
Phoenix, Arizona

ACSM Team Physician, Course, Part I
February 24-28, 2010
Las Vegas, Nevada

ACSM's 14th Health & Fitness Summit & Exposition
April 7-10, 2010
Austin, Texas

ACSM's 57th Annual Meeting and World Congress on Exercise is Medicine™
June 2-5, 2010
Baltimore, Maryland



AMERICAN COLLEGE of SPORTS MEDICINE
LEADING THE WAY

Street Address: 401 W Michigan St.
Indianapolis, IN 46202-3233 USA

Mailing Address: P.O. Box 1440
Indianapolis, Indiana, 46208-1440 USA

Telephone: (317) 637-9200
FAX: (317) 634-7817
Web Site: www.acsm.org
Federal I.D. Number: 23-6390952

Standard of Determination for Research Misconduct

- There be a **significant departure** from accepted practices of the relevant research community; and
- The misconduct was committed **intentionally, knowingly, or recklessly**; and
- The allegation be proven by a **preponderance of the evidence**

"I tend not to believe people. People lie. The evidence doesn't lie."

Gil Grissom, CSI



Serious Deviation from Common Practice

- ??????????????????????

Serious Deviation from Common Practice

- Stealing, destroying, or damaging the research property of others with the intent to alter the research record
- Listing someone's name as an author on a publication, without his/her knowledge or permission

Serious Deviation from Common Practice

- Misrepresenting background information, including biographical data, citation of publications, or status of manuscripts
- Abuse of confidentiality: taking or releasing the ideas or data of others which were shared with the legitimate expectation of confidentiality, e.g., stealing ideas from others' grant proposals, award applications, or manuscripts for publication when one is a reviewer for granting agencies or journals

Question

- Do we deal with any other bad things?
- Sometimes

MICHIGAN STATE
UNIVERSITY

Research Integrity Matters

Research Integrity Council

grad.msu.edu
vprgs.msu.edu



Disclosure

Report potential conflicts of interest

Honesty

Recognition

Confidentiality

Disclosure

Compliance

Protection

Collegiality

Communication

MICHIGAN STATE
UNIVERSITY

Research Integrity Matters

Research Integrity Council

grad.msu.edu
vprgs.msu.edu



Compliance

Understand and follow the rules

Honesty

Recognition

Confidentiality

Disclosure

Compliance

Protection

Collegiality

Communication

MICHIGAN STATE UNIVERSITY

Research Integrity Matters

Research Integrity Council

grad.msu.edu
vprgs.msu.edu



Protection

Respect research participants

- Honesty
- Recognition
- Confidentiality
- Disclosure
- Compliance
- Protection
- Collegiality
- Communication

- **“Unacceptable Research Practices”** means practices that do not constitute Misconduct but that violate applicable laws, regulations, or other governmental requirements, or University rules or policies, of which the Respondent had received notice or of which the Respondent reasonably should have been aware, for proposing, performing, reviewing, or reporting Research or Creative Activities.

What about individuals who are always on the edge?



- “***Questionable Research Practices***” means practices that do not constitute Misconduct or Unacceptable Research Practices but that require attention because they could erode confidence in the integrity of Research or Creative Activities.

MICHIGAN STATE
UNIVERSITY

Research Integrity Matters

Research Integrity Council

grad.msu.edu
vprgs.msu.edu



Collegiality

Work well with others

Honesty Recognition Confidentiality Disclosure Compliance Protection Collegiality Communication

Question

- What percentage of potential allegations coming to our office is associated with some sort of previous conflict between/among the parties involved?
- ~ 90%!!

What's the Score?

- We average about 6-10 new cases per year

What's the Score?

- Every case undergoes a Preliminary Assessment
 - Approximately 1/3 cases end there
- Of the 2/3 of cases that move on,
 - 1/3 end with an Inquiry
 - 2/3 move on to a full Investigation

Causes of research misconduct?

(Davis et al, 2007)

- Individual
- Situational
- Organizational
- Structural
- Cultural

Recent Cases

- Hypothetical, of course

Recent Cases

- Falsification/fabrication of data by a student
 - Complainant was faculty, and students
- Lab supervision could have been better

Recent Cases

- Plagiarism in a dissertation by a student
 - Complainant was external to MSU
- Dissertation committee may not have provided proper oversight

Recent Cases

- Serious Deviation and Plagiarism by a student
 - Complainants were faculty members
- Possible prior acts by Respondent drove the Allegation

Recent Cases

- Plagiarism by a faculty member
 - Complainant was a student
- Case complicated by “agreements” made among administrators, faculty member, and student, that are not clearly understood by all parties

Recent Cases

- Unacceptable Research Practices by faculty member
 - Complainant was a student
- Graduate Dean helped student secure another lab for doing the right thing

You can report anonymously

Misconduct Hotline



[HOME](#)

[PROCESS](#)

[LOCAL REPORTING](#)

[FAQS](#)

You can report anonymously

Submit a Report

Online Hotline

Visits to the reporting website are not tracked. You can choose to provide your name or remain anonymous.

[Submit a report online »](#)

Phone Hotline

Anonymous calls can be made 24 hours a day, seven days a week.

Dial **(800) 763-0764**

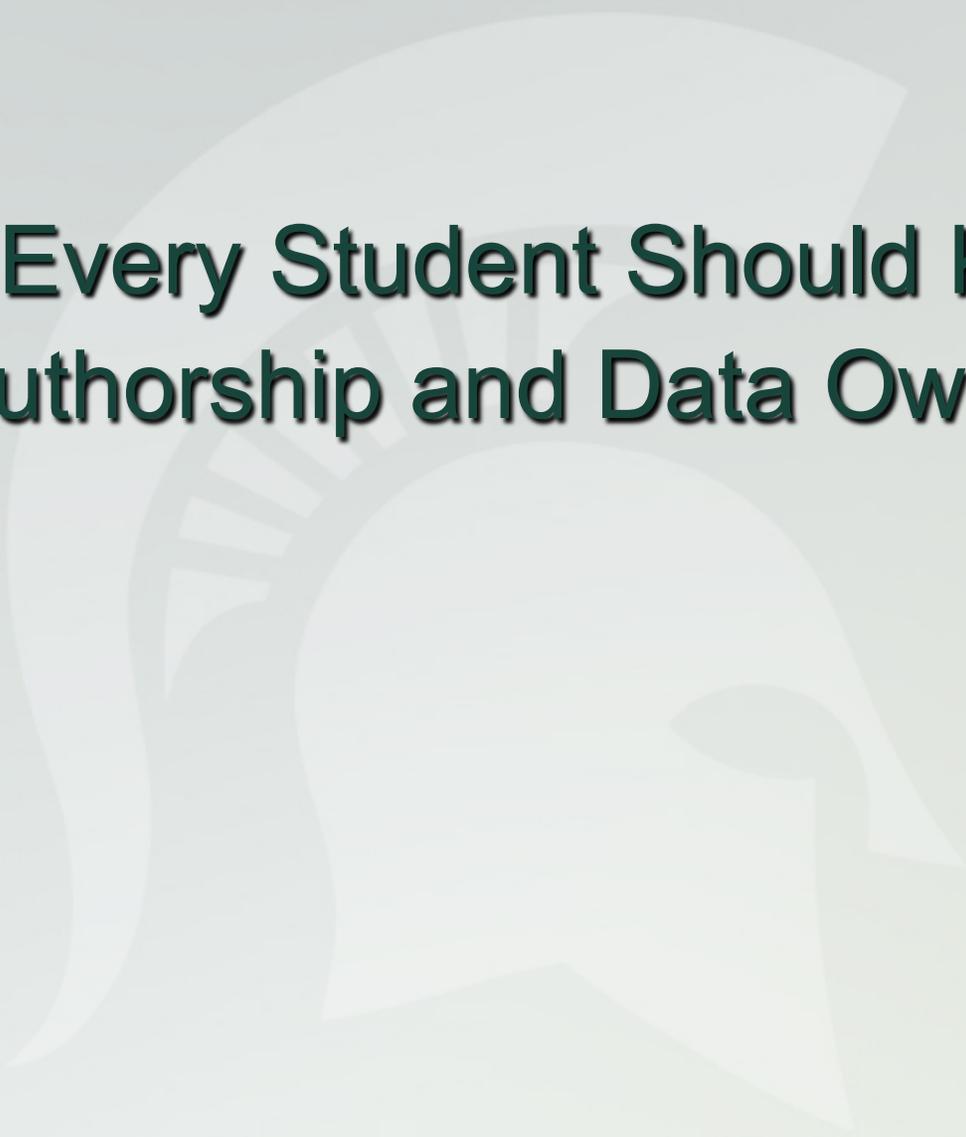


IF YOU
SEE SOMETHING
SAY SOMETHING

And now for something completely different



What Every Student Should Know About Authorship and Data Ownership



Whose name goes where on the paper, and whose data are they anyhow?



Rationale

- Role of peer-reviewed research
- Importance in faculty evaluations
- Increasing level of collaborative efforts
- Student education

The Future of Peer Reviewed Publishing?

COMMENTARY

The Ethics of Scientific Publishing: Black, White, and “Fifty Shades of Gray”



Anthony L. Zietman, MD, FASTRO

Department of Radiation Oncology, Massachusetts General Hospital, Boston, Massachusetts

Received Feb 21, 2017, and in revised form Jun 2, 2017. Accepted for publication Jun 8, 2017.



Francis Crick and James Watson





James Watson and Francis Crick

NO. 4336 April 25, 1953 NATURE 7

equipment, and to Dr. G. B. R. Deacon and the captain and officers of R.R.S. *Discovery II* for their part in making the observations.

¹Yang, P. L., *Discuss. H. and J. Soc. Phys.*, **40**, 144 (1946).

²Langer-Spang, M. S., *Ann. Roy. Soc. (Ser. 2)*, **20**, 392, 400 (1950).

³Lee, H. E., *World Wide Papers in Phys. Chem.*, **1**, 11 (1948).

⁴Elmer, V. W., *Arch. Med. Res.*, **2**, 103 (1951).

MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has several features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey¹. They kindly made their manuscript available to us in advance of publication. Their model consists of three later-twisted chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams its axis, not the fibre axis. Without the axial hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Frenkel (in press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we call our structure

our model. We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. The structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate ester groups joining 3'- β -deoxyribose residues with 5'- β -linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequence of the atoms in the two chains run in opposite directions. Each chain loosely resembles Frenkel's model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Frenkel's standard configuration, the sugar being roughly perpendicular to the attached base. There



This structure is a model. It is not intended to be a final structure. It is suggested as a starting point for discussion and for the building of a more complete model.

is a residue on each chain every 2.4 Å, in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that structure repeats after 10 residues on each chain, i.e. after 24 Å. The distance of a phosphate from the fibre axis is 10 Å. As the phosphates on the outside, chains have easy access to them. The structure is an open one, and its water content is rather high. At lower water contents we expect the bases to tilt so that the structure becomes more compact.

The exact nature of the structure is not in which the two chains are held together by uracil and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are held together in pairs, a single base from one chain hydrogen-bonded to a single base from the other chain, so that the two are side by side with their *o*-*o*-orientations. One of the pair must be a purine, the other a pyrimidine for bonding to occur. Hydrogen bonds are made as follows: purine position 1 to pyrimidine position 4; purine position 6 to pyrimidine position 2.

If it is assumed that the bases only occur in structure in the most possible continuous (that is, with the keto rather than the enol tautomers) it is found that only specific pairings can be made together. These pairs are: adenine with thymine (pyrimidine), and guanine with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then the sequence of the other member must be thymine; similarly guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases are formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally^{2,3} that the *o*-*o* sequence of adenine or thymine, and the *o*-*o* sequence of guanine or cytosine, are always very close to each other in deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, the extra oxygen atom would make too close the van der Waals contacts.

The previously published X-ray data⁴ on *D. rubens* nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is compatible with the experimental data, but it is regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented here when we devised our structure, which rests mainly though entirely on published experimental data and on chemical arguments.

It is not escaped our notice that the repeating we have postulated immediately suggest possible copying mechanism for the genetic material. Full details of the structure, including the distances assumed in building it, together with *o*-*o* orientations for the atoms, will be published elsewhere.

We are greatly indebted to Dr. Jerry Donohue for constant advice and criticism, especially on atomic distances. We have also been stimulated by a knowledge of the general nature of the model by experimental results and ideas of Dr. M. F. Wilkins, Dr. R. E. Franklin and their co-workers.

738

NATURE

April 25, 1953 VOL. 1

King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infarcted Paralysis.

J. D. WATSON

F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems, Cavendish Laboratory, Cambridge.

April 2

¹Pauling, L., and Corey, R. B., *Nature*, **157**, 680 (1946); *Proc. U.S. Nat. Acad. Sci.*, **30**, 41 (1944).

²Farberg, V., *Acta Chem. Scand.*, **6**, 624 (1952).

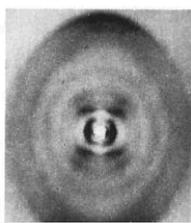
³Chargaff, E., *Experiments in Biochemistry*, 5, *Proceedings of the Royal Society, London*, **1952**.

⁴Wright, D. E., *J. Am. Physiol.*, **34**, 26 (1952).

⁵Watson, J. D., *Proc. Roy. Soc. London*, **1953**, *in press*.

⁶Watson, J. D., *Proc. Roy. Soc. London*, **1953**, *in press*.

⁷Watson, J. D., *Proc. Roy. Soc. London*, **1953**, *in press*.



Acknowledgement

- We are much indebted to Dr. Jerry Donohue's constant advice and criticism, especially on atomic disturbances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. Wilkins, Dr. R.E. Franklin and their co-workers.



Maurice Wilkins



Maurice Wilkins

738

NATURE April 25, 1953 VOL. 171

King's College, London. One of us (J.D.W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems, Cavendish Laboratory, Cambridge, April 2.

- ¹ Pauling, L., and Corey, R. B., *Nature*, 171, 346 (1953); *Proc. U.S. Nat. Acad. Sci.*, 38, 81 (1952).
² Pauling, L., *Acta Chem. Scand.*, 6, 494 (1952).
³ Chargaff, E., for references see Zamenhof, S., *Investigations*, G. and Chargaff, E., *Biochim. et Biophys. Acta*, 9, 462 (1952).
⁴ Wyatt, G. B., *J. Gen. Physiol.*, 36, 261 (1952).
⁵ Astbury, W. T., *Temp. Soc. Rep. Biol.*, 1, 276 (1952).
⁶ Wilkins, M. H. F., and Randall, J. T., *Biochim. et Biophys. Acta*, 10, 152 (1953).

Molecular Structure of Deoxyribose Nucleic Acids

WHILE the biological properties of deoxyribose nucleic acid suggest a molecular structure containing great complexity, X-ray diffraction studies described here (cf. Astbury⁴) show the basic molecular configuration has great simplicity. The purpose of this communication is to describe, in a preliminary way, some of the experimental evidence for the polynucleotide chain configuration being helical, and existing in this form when in the natural state. A fuller account of the work will be published shortly.

The structure of deoxyribose nucleic acid is the same in all species (although the nitrogen base ratios alter considerably in nucleoprotein, extracted or in cells, and in purified nucleic acid). The same linear group of polynucleotide chains may pack together parallel in different ways to give crystalline^{1,2}, semi-crystalline or paracrystalline material. In all cases the X-ray diffraction photograph consists of two regions, one determined largely by the regular spacing of nucleotides along the chain, and the other by the longer spacings of the chain configuration. The sequence of different nitrogen bases along the chain is not made visible.

Oriented paracrystalline deoxyribose nucleic acid (structure B' in the following communication by Franklin and Gosling) gives a fibre diagram as shown in Fig. 1 (cf. ref. 6). Astbury suggested that the strong 3.4-Å reflexion corresponded to the internucleotide repeat along the fibre axis. The ~34-Å layer lines, however, are not due to a repeat of a polynucleotide composition, but to the chain configuration repeat, which occurs strong diffraction as the nucleotide chains have higher density than the interstitial water. The absence of reflexions on or near the meridian immediately suggests a helical structure with axis parallel to fibre length.

Diffraction by Helices

It may be shown³ (also Stokes, unpublished) that the intensity distribution in the diffraction pattern of a series of points equally spaced along a helix is given by the square of Bessel functions. A uniform continuous helix gives a series of layer lines of spacing corresponding to the helix pitch, the intensity distribution along the *n*th layer line being proportional to the square of J_n , the *n*th order Bessel function. A straight line may be drawn approximately through

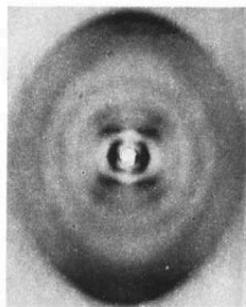


Fig. 1. Fibre diagram of deoxyribose nucleic acid from *B. coli*. Fibre axis vertical.

the innermost maxima of each Bessel function and the origin. This line makes with the equator the angle which is equal to the angle between an element of the helix and the helix axis. If a unit repeats *n* times along the helix there will be a meridional reflexion (J_0^n) on the *n*th layer line. The helical configuration produces side-bands on this fundamental frequency, the effects being to reproduce the intensity distribution about the origin around the new origin, on the *n*th layer line, corresponding to *C* in Fig. 2.

We will now briefly analyse in physical terms some of the effects of the shape and size of the repeat unit or nucleotide on the diffraction pattern. First, if the nucleotide consists of a unit having circular symmetry about an axis parallel to the helix axis, the whole diffraction pattern is modified by the form factor of the nucleotide. Second, if the nucleotide consists of a series of points on a radius at right-angles to the helix axis, the phases of maxima scattered by the helices of different diameter passing through each point are the same. Summation of the corresponding Bessel functions gives reinforcement for the inner-

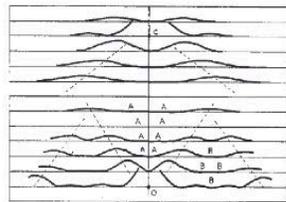


Fig. 2. Diffraction pattern of system of helices corresponding to structure of deoxyribose nucleic acid. The squares of Bessel functions are plotted about *O* on the equator and on the first, second, third and fifth layer lines for all of the nucleotide units at 20-Å diameter and regularly distributed along a radius. The squares of a given radius being proportional to the radius. About *C* on the fifth layer line the diffraction pattern is plotted for an outer diameter of 12 Å.

NO. 4356 April 25, 1953

NATURE

739

most maximum and, in general, owing to phase differences, association of all other maxima. Such a system of helices (corresponding to a spiral staircase with the core removed) differs mainly over a limited angular range, behaving, in fact, like a periodic arrangement of flat plates inclined at a fixed angle to the axis. Third, if the nucleotide is extended so as to form a circle in a plane at right-angles to the helix axis, and with centre at the axis, the intensity of the system of Bessel function layer-line streaks emanating from the origin is modified owing to the phase difference of radiation from the helices down through one cross on the nucleotide. The form factor is that of the series of points in which the helices intersect a plane drawn through the helix axis. This part of the diffraction pattern is then repeated as a whole with origin at *C* (Fig. 2). Hence this aspect of nucleotide shape affects the central and peripheral regions of each layer line differently.

Interpretation of the X-Ray Photograph

It must first be decided whether the structure consists of essentially one helix giving an intensity distribution along the layer lines corresponding to J_0, J_1, J_2, \dots or two similar co-axial helices of twice the above size and relatively displaced along the axis a distance equal to half the pitch giving J_0, J_1, J_2, \dots or three helices, etc. Examination of the width of the layer-line streaks suggests the latter interpretation more closely to J_1, J_2, J_3, \dots than to J_0, J_1, J_2, \dots . Hence the dominant helix has a pitch of ~34 Å, and, from the angle of the helix, its diameter is found to be ~20 Å. The strong equatorial reflexion at ~17 Å suggests that the helix has a maximum diameter of ~20 Å and is irregularly packed with little interpretation. Apart from the width of the Bessel function streaks, the probability of the helices having twice the above dimensions is also made unlikely by the absence of an equatorial reflexion at ~21 Å. To obtain a reasonable number of nucleotides per unit volume in the fibre, two or three intertwined co-axial helices are required, there being ten nucleotides on one turn of each helix.

The absence of reflexions on or near the meridian, an empty region A.A. on Fig. 2 is a direct consequence of the helical structure. On the photograph there is also a relatively empty region on and near the equator, corresponding to region B.B. on Fig. 2. As discussed above, this absence of secondary Bessel function maxima can be produced by a radial distribution of the nucleotide shape. To make the layer-line streaks sufficiently narrow, it is necessary to place a large fraction of the nucleotide mass at ~20-Å diameter. In Fig. 2 the squares of Bessel functions are plotted for half the mass at 20-Å diameter, and the rest distributed along a radius, the mass at a given radius being proportional to the radius.

On the zero layer line there appears to be a marked $J_0^2 + J_0^2 + J_0^2 + J_0^2$, etc., respectively. This means that, in projection on a plane at right-angles to the fibre axis, the outer part of the nucleotide is relatively concentrated, giving rise to high-density regions spaced at ~6 Å apart around the circumference of a circle of 20-Å diameter. On the fifth layer line two J_5 functions overlap and produce a strong reflexion. On the sixth, seventh and eighth layer lines the maxima correspond to a helix of diameter ~12 Å. Apparently it is only the central region of the helix structure which is well divided by the 3.4-Å spacing, the outer

parts of the nucleotide overlapping to form a continuous helix. This suggests the presence of nitrogen bases arranged like a pile of pancakes⁴ in the central regions of the helical system.

There is a marked absence of reflexions on layer lines beyond the tenth. Disorientation in the specimen will reduce more extension along the layer lines of the Bessel function streaks on the seventh, twelfth and thirteenth layer lines than on the ninth, eighth and seventh. For this reason the reflexions on the higher-order layer lines will be less readily visible. The form factor of the nucleotide is also probably causing diminution of intensity in this region. Tinting of the nitrogen bases could have such an effect.

Reflections on the equator are rather indistinct for determination of the radial distribution of density in the helical system. There are, however, indications that a high-density shell, as suggested above, occurs at diameter ~20 Å.

The material is apparently not completely paracrystalline, as sharp spots appear in the central region of the second layer line, indicating a partial degree of order of the helical units relative to one another in the direction of the helix axis. Photograph similar to Fig. 1 have been obtained from sodium nucleate from calf and pig thymus, wheat germ, herring sperm, human tissue and *T. bacteriophage*. The most marked correspondence with Fig. 2 is shown by the exceptional photograph obtained by our colleagues, R. E. Franklin and R. G. Gosling, from calf thymus deoxyribose nucleate (see following communication).

It must be stressed that some of the above discussion is not without ambiguity, but in general there appears to be reasonable agreement between the experimental data and the kind of model described by Watson and Crick (see also preceding communication).

It is interesting to note that if there are ten phosphate groups arranged on each helix of diameter 20 Å and pitch 34 Å, the phosphate ester backbone chain is to an almost fully extended state. Hence, when sodium nucleate fibres are stretched, the helix is evidently extended in length like a spiral spring in tension.

Structure in vivo

The biological significance of a two-chain nucleic acid unit has been noted (see preceding communication). The evidence that the helical structure discussed above does, in fact, exist in intact biological systems is briefly as follows:

Sperm heads. It may be shown that the intensity of the X-ray spectra from crystalline sperm heads is determined by the helical form factor in Fig. 2. Centrifuged trout sperm give the same pattern as the dried and rehydrated or washed sperm heads used previously⁵. The sperm head fibre diagram is also given by extracted or crystallized nucleoproteins or extracted calf thymus nucleohistone.

Bacteriophage. Centrifugal pellets of *T4* phage photographed with X-rays while sealed in a cell with mica windows give a diffraction pattern containing the main features of paracrystalline sodium nucleate so distinct from that of crystalline nucleoprotein. This confirms current ideas of phage structure.

Transforming principle. In collaboration with H. Dikshis-Taylor, Active deoxyribose nucleate allowed to dry at ~60 per cent humidity has the same crystalline structure as certain samples⁶ of sodium thymonucleate.

740

NATURE

April 25, 1953 VOL. 171

We wish to thank Prof. J. T. Randall for encouragement; Prof. E. Chargaff, R. Siger, J. A. V. Butler and Drs. J. D. Watson, J. D. Smith, L. Hamilton, J. C. Wiley and G. R. Wyatt for supplying material without which this work would have been impossible; also Drs. J. D. Watson and Mr. F. H. C. Crick for stimulation, and our colleagues R. E. Franklin, R. G. Gosling, G. L. Brown and W. E. Soles for discussion. One of us (M. H. F. W.) wishes to acknowledge the award of a University of Wales Fellowship.

M. H. F. WILKINS

Medical Research Council Biophysics

Research Unit,

A. R. SPOWELL

R. B. WATSON

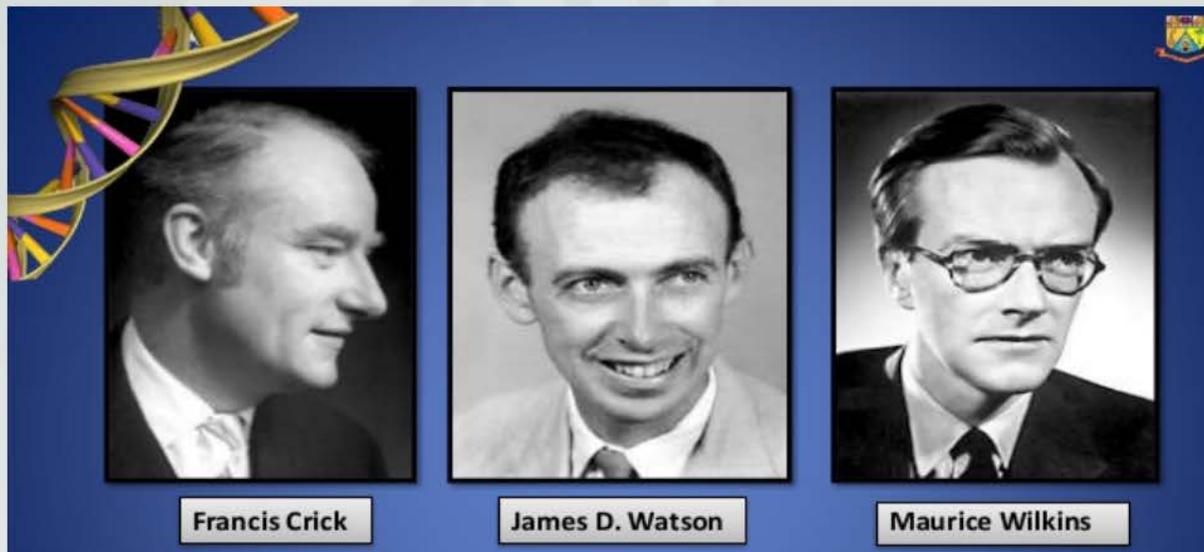
Whitworth Physics Laboratory,

King's College, London.

April 2.

¹ Astbury, W. T., *Temp. Soc. Rep. Biol.*, 1, 276 (1952).
² Ibid., 1, 277 (1952).





Francis Crick

James D. Watson

Maurice Wilkins

- The Nobel Prize in Physiology or Medicine 1962 was awarded jointly to Francis Harry Compton Crick, James Dewey Watson and Maurice Hugh Frederick Wilkins "for their discoveries concerning the **molecular structure of nucleic acids and its significance for information transfer in living material**" (1953).



So what's the problem?

A faint, light-colored image of a Spartan helmet is centered in the background of the slide. The helmet features a prominent crest with a series of vertical ridges. The overall image is semi-transparent, allowing the text to be clearly visible over it.



Rosalind Franklin



Rosalind Franklin

740

NATURE April 25, 1953 Vol. 171

We wish to thank Prof. J. T. Randall for encouragement; Profs. E. Chargaff, R. Siger, J. A. V. Butler and Drs. J. D. Watson, J. D. Smith, L. Hamilton, J. C. White and G. R. Wyatt for supplying material without which this work would have been impossible; also Drs. J. D. Watson and Mr. F. H. C. Crick for stimulation, and our colleagues R. E. Franklin, R. G. Gosling, G. L. Brown and W. E. Secols for discussion. One of us (H. R. W.) wishes to acknowledge the award of a University of Wales Fellowship.

M. H. F. WILKINS
Medical Research Council Biophysics
Research Unit,

A. R. STOKES
H. R. WILSON
Wheatstone Physics Laboratory,
King's College, London,
April 2.

- ¹ Ashbury, W. T., *Proc. Roy. Soc. Lond., Ser. B*, **1942**, **35**, 192.
² Riley, D. P., and Oster, G., *Biochim. et Biophys. Acta*, **7**, 536 (1951).
³ Wilkins, M. H. F., Gosling, R. G., and Stokes, W. E., *Nature*, **167**, 719 (1951).
⁴ Ashbury, W. T., and Bell, T. O., *Cold Spring Harbor Symp. Quant. Biol.*, **8**, 109 (1938).
⁵ Cochran, W., Crick, F. H. C., and Vand, V., *Acta Cryst.*, **8**, 581 (1952).
⁶ Wilkins, M. H. F., and Randall, J. T., *Biochim. et Biophys. Acta*, **10**, 162 (1952).

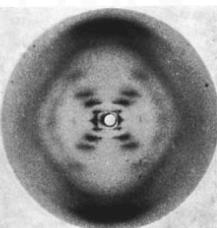
Molecular Configuration in Sodium Thymonucleate

SODIUM thymonucleate fibres give two distinct types of X-ray diagram. The first corresponds to a crystalline form, structure *A*, obtained at about 75 per cent relative humidity; a study of this is described in detail elsewhere.¹ At higher humidities a different structure, structure *B*, showing a lower degree of order, appears and persists over a wide range of ambient humidity. The change from *A* to *B* is reversible. The water content of structure *B* fibres which undergo this reversible change may vary from 40–50 per cent to several hundred per cent of the dry weight. Moreover, some fibres never show structure *A*, and in these structure *B* can be obtained with an even lower water content.

The X-ray diagram of structure *B* (see photograph) shows in striking manner the features characteristic of helical structures, first worked out in this laboratory by Stokes (unpublished) and by Crick, Cochran and Vand.² Stokes and Wilkins first proposed such structures for nucleic acid as a result of direct studies of nucleic acid fibres, although a helical structure had been previously suggested by Furlberg (thesis, London, 1949) on the basis of X-ray studies of nucleosides and nucleotides.

While the X-ray evidence cannot, at present, be taken as direct proof that the structure is helical, other considerations discussed below make the existence of a helical structure highly probable.

Structure *B* is derived from the crystalline structure *A* when the sodium thymonucleate fibres take up quantities of water in excess of about 40 per cent of their weight. The change is accompanied by an increase of about 30 per cent in the length of the fibre, and by a substantial re-arrangement of the molecule. It therefore seems reasonable to suppose that in structure *B* the structural units of sodium thymonucleate (molecules or groups of molecules) are relatively free from the influence of neighbouring



Sodium thymonucleate molecule from calf thymus. Structure *B*.

molecule, each unit being shielded by a sheath of water. Each unit is then free to take up its least-energy configuration independently of its neighbours and, in view of the nature of the long-chain molecules involved, it is highly likely that the general form will be helical. If we adopt the hypothesis of a helical structure, it is immediately possible, from the X-ray diagram of structure *B*, to make certain deductions as to the nature and dimensions of the helix.

The numerous maxima on the first, second, third and fifth layer lines lie approximately on straight lines radiating from the origin. For a smooth single-strand helix the structure factor on the *n*th layer line is given by:

$$F_n = J_0(2\pi rR) \exp i n(\phi + \frac{1}{2}\pi)$$

where $J_0(x)$ is the 0th-order Bessel function of x , r is the radius of the helix, and R and ϕ are the radial and azimuthal co-ordinates in reciprocal space; this expression leads to an approximately linear array of intensity maxima of the type observed, corresponding to the first maxima in the functions J_0, J_1, J_2 , etc.

If, instead of a smooth helix, we consider a series of residues equally spaced along the helix, the transform in the general case treated by Crick, Cochran and Vand is more complicated. But if there is a whole number, m , of residues per turn, the form of the transform is as for a smooth helix with the addition, only, of the same pattern repeated with its origin at heights $m\pi, 2m\pi, \dots$ etc. (i.e. the fibre-axis period).

In the present case the fibre-axis period is 34 Å, and the very strong reflexion at 3.4 Å lies on the tenth layer line. Moreover, lines of maxima radiating from the 3.4 Å reflexion as from the origin are visible on the fifth and lower layer lines, having a J_0 maximum coincident with that of the origin series on the fifth layer line. (The strong outer streaks which apparently radiate from the 3.4 Å maximum are not, however, so easily explained.) This suggests strongly that there are exactly 10 residues per turn of the helix. If this is so, then from a measurement of R_n , the position of the first maximum on the *n*th layer line (for $n = 5$), the radius of the helix, can be obtained. In the present instance, measurements of R_1, R_2, R_3 and R_4 all lead to values of r of about 10 Å.

No. 4256 April 25, 1953 NATURE

741

Since this linear array of maxima is one of the strongest features of the X-ray diagram, we must conclude that a crystallographically important part of the molecule lies on a helix of this diameter. This can only be the phosphate groups or phosphorus atoms.

If ten phosphorus atoms lie on one turn of a helix of radius 10 Å, the distance between neighbouring phosphorus atoms in a molecule is 7.1 Å. This corresponds to the $P \dots P$ distance in a fully extended molecule, and therefore provides a further indication that the phosphates lie on the outside of the structural unit.

Thus, our conclusions differ from those of Pauling and Corey,³ who proposed for the nucleic acids a helical structure in which the phosphate groups form a dense core.

We must now consider briefly the equatorial reflexions. For a single helix the series of equatorial maxima should correspond to the maxima in $J_0(2\pi rR)$. The maxima on our photograph do not, however, fit this function for the value of r deduced above. There is a very strong reflexion at about 24 Å, and then only a faint sharp reflexion at 9.0 Å, and two diffuse bands around 5.5 Å and 4.9 Å. This lack of agreement is, however, to be expected, for we know that the helix so far considered can only be the most important member of a series of coaxial helices of different radii; the non-phosphate parts of the molecule will lie on inner co-axial helices, and it can be shown that, whereas these will not appreciably influence the innermost maxima on the layer lines, they may have the effect of destroying or shifting both the equatorial maxima and the outer maxima on other layer lines.

Thus, if the structure is helical, we find that the phosphate groups or phosphorus atoms lie on a helix of diameter about 20 Å, and the sugar and base groups must accordingly be turned inwards towards the helical axis.

Considerations of density show, however, that a cylindrical repeat unit of height 34 Å and diameter 20 Å must contain many more than ten nucleotides.

Since structure *B* often exists in fibres with low water content, it seems that the density of the helical unit cannot differ greatly from that of dry sodium thymonucleate, 1.63 gm./cm.³. If the water in fibres of high water-content being situated outside the structural unit. On this basis we find that a cylinder of radius 10 Å and height 34 Å would contain thirty-two nucleotides. However, there might possibly be some slight inter-penetration of the cylindrical units in the dry state making their effective radius rather less. It is therefore difficult to decide, on the basis of density measurements alone, whether one repeating unit contains ten nucleotides on each of two or on each of three co-axial molecules. (If the effective radius were 5 Å, the cylinder would contain twenty nucleotides.) Two other arguments, however, make it highly probable that there are only two co-axial molecules.

First, a study of the Patterson function of structure *A*, using superposition methods, has indicated⁴ that there are only two chains passing through a primitive unit cell in this structure. Since the *A* and *B* structures are readily reversible, it seems very unlikely that the molecules would be grouped in three in structure *B*. Secondly, from measurements on the X-ray diagram of structure *B* it can readily be shown that, whether the number of chains per unit is two or three, the chains are not equally spaced along the

fibre axis. For example, three equally spaced chains would mean that the outer layer line depended on J_{30} , and would lead to a helix of diameter about 60 Å. This is many times larger than the primitive unit cell in structure *A*, and absurdly large in relation to the dimensions of nucleotides. Three unequally spaced chains, on the other hand, would be crystallographically non-equivalent, and this, again, seems unlikely. It therefore seems probable that there are only two co-axial molecules and that these are unequally spaced along the fibre axis.

Thus, while we do not attempt to offer a complete interpretation of the fibre-diagram of structure *B*, we may state the following conclusions. The structure is probably helical. The phosphate groups lie on the outside of the structural unit, on a helix of diameter about 20 Å. The structural unit probably consists of two co-axial molecules which are not equally spaced along the fibre axis, their mutual displacement being such as to account for the variation of observed intensities of the innermost maxima on the layer lines: if one molecule is displaced from the other by about three-eighths of the fibre-axis period, this would account for the absence of the fourth layer line maxima and the weakness of the sixth. Thus our general ideas are not inconsistent with the model proposed by Watson and Crick in the preceding communication.

The conclusion that the phosphate groups lie on the outside of the structural unit has been reached previously by quite other reasoning.⁵ Two principal lines of argument were involved. The first derives from the work of Gulland and his collaborators,⁶ who showed that even in aqueous solution the —CO and —NH₂ groups of the base are inaccessible and cannot be titrated, whereas the phosphate groups are fully accessible. The second is based on our own observations⁷ on the way in which the structural units in structures *A* and *B* are progressively separated by an excess of water, the process being a continuous one which leads to the formation first of a gel and ultimately to a solution. The hygroscopic part of the molecule may be presumed to lie in the phosphate groups ((C₂H₃O₂)₂PO₃Na and (C₂H₃O₂)₂PO₃Na are highly hygroscopic), and the simplest explanation of the above process is that these groups lie on the outside of the structural units. Moreover, the ready availability of the phosphate groups for interaction with proteins can most easily be explained in this way.

We are grateful to Prof. J. T. Randall for his interest and to Drs. F. H. C. Crick, A. R. Stokes and M. H. F. Wilkins for discussion. One of us (R. E. F.) acknowledges the award of a Turner and Newall Fellowship.

ROSALIND F. FRANKLIN*

R. G. GOSLING†

Wheatstone Physics Laboratory,
King's College, London.

April 4.

* Now at Hammersmith College Research Laboratories, 21 Turnham Green, London, W.11.

† Now at Hammersmith College Research Laboratories, 21 Turnham Green, London, W.11.

¹ Franklin, R. E., and Gosling, R. G. (in this issue).

² Cochran, W., Crick, F. H. C., and Vand, V., *Acta Cryst.*, **8**, 591 (1952).

³ Pauling, L., Corey, R. E., and Branson, H. R., *Proc. U.S. Nat. Acad. Sci.*, **37**, 302 (1951).

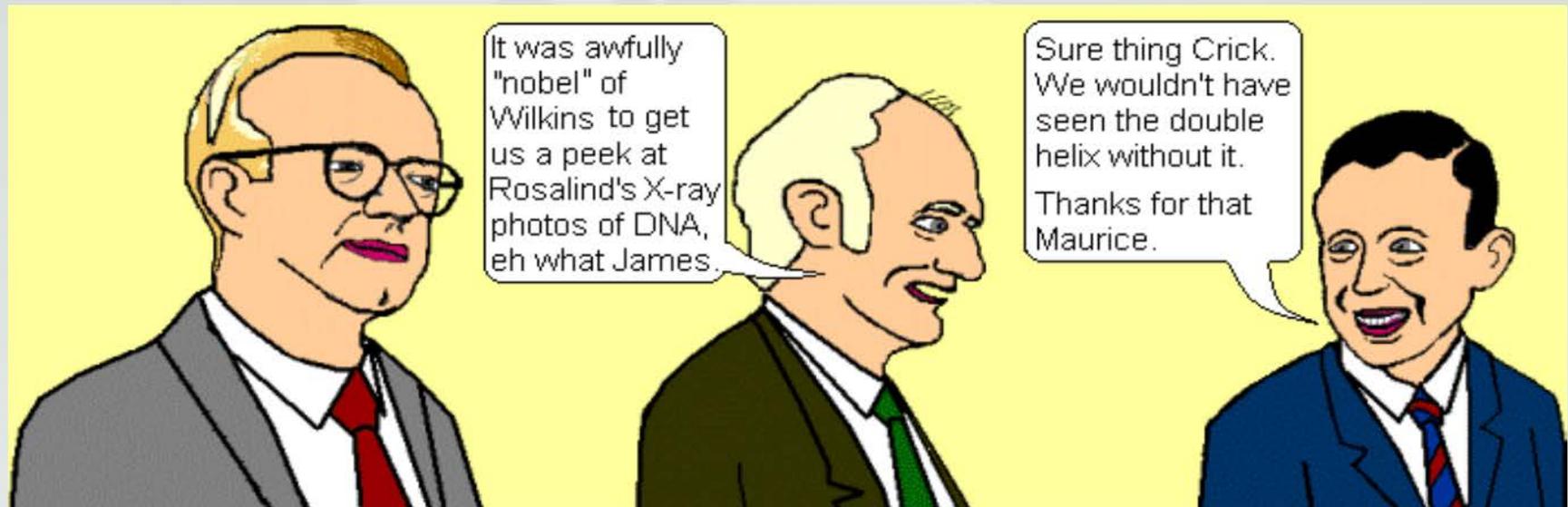
⁴ Pauling, L., and Corey, R. E., *Proc. U.S. Nat. Acad. Sci.*, **39**, 84 (1953).

⁵ Ashbury, W. T., *Cold Spring Harbor Symp. on Quant. Biol.*, **12**, 12 (1947).

⁶ Pauling, L., and Gosling, R. G. (to be published).

⁷ Gulland, J. M., and Jordan, H. O., *Cold Spring Harbor Symp. on Quant. Biol.*, **8**, 1 (1952).

⁸ Pauling, W. A., and Corey, R. E., *Chem. Zvest.*, **89**, 165 (1946).



History

- The Nobel Prize in Medicine 1962



Francis Harry Compton Crick



James Dewey Watson



Maurice Hugh Frederick Wilkins



Rosalind Franklin
(Died of cancer 1958)

Did Rosalind Franklin get shafted?



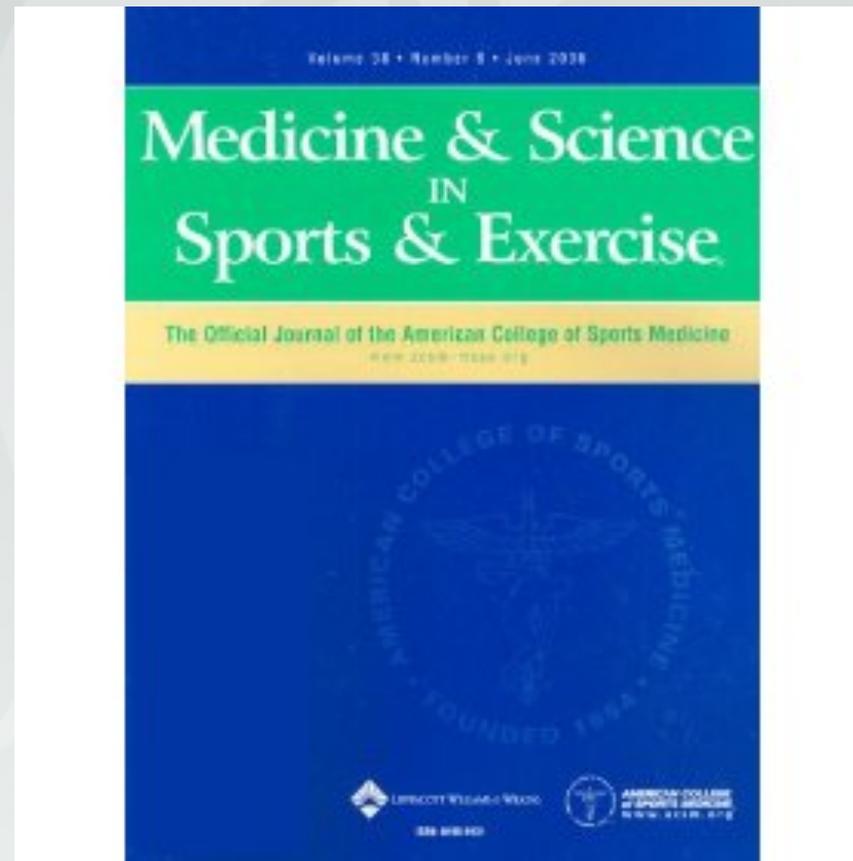
- The author list should include all appropriate researchers and no others. Authorship provides credit for a researcher's contributions to a study and carries accountability. The Nature journals do not prescribe the kinds of contributions that warrant authorship but encourage transparency by publishing author contributions statements. Nature journals editors are not in a position to investigate or adjudicate authorship disputes before or after publication. Such disagreements if they cannot be resolved amongst authors should be brought up to the relevant institutional authority.
 - Nature, 2014

Who Qualifies for Authorship?

- Idea Person?
- Data Collectors?
 - Paid vs Unpaid
- Statistician?
- Head of Lab?
- Students?
- Colleagues?
- Relatives?



Medicine and Science in Sports and Exercise



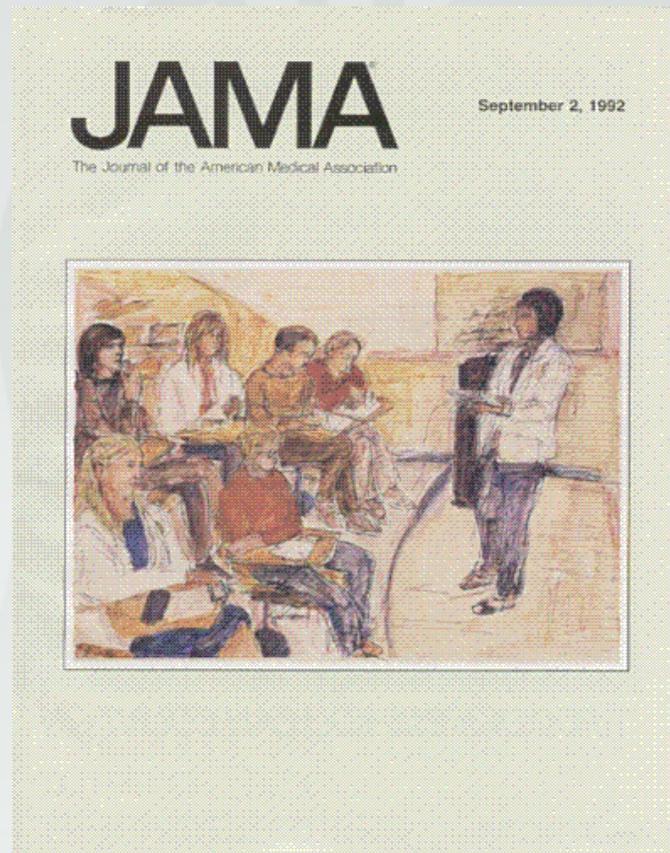
- To be an author, each individual shall have contributed to the manuscript in at least two (2) of the following areas:
 - * **Significant** manuscript writer
 - * **Significant** manuscript reviewer/reviser
 - * Concept and design
 - * Data acquisition
 - * Data analysis and interpretation
 - * Statistical expertise

- To be an author, each individual shall have contributed to the manuscript in at least two (2) of the following areas:
 - * **Significant** manuscript writer
 - * **Significant** manuscript reviewer/reviser
 - * Concept and design
 - * Data acquisition
 - * Data analysis and interpretation
 - * Statistical expertise
- Manuscripts with more than six (6) authors require justification for exceeding that number. The Journal reserves the right to ask authors to reduce the number of authors.

What about an *abstract* submission to a research meeting?

Are the rules different?

JAMA



1. Authorship Responsibility, Criteria, and Contributions. Each author should meet all criteria below (A, B, C, and D) and should indicate general and specific contributions by reading criteria A, B, C, and D and checking the appropriate boxes.

- A. I certify that
 - the manuscript represents original and valid work and that neither this manuscript nor one with substantially similar content under my authorship has been published or is being considered for publication elsewhere, except as described in an attachment, and copies of closely related manuscripts are provided; and
 - if requested, I will provide the data or will cooperate fully in obtaining and providing the data on which the manuscript is based for examination by the editors or their assignees; and
 - for papers with more than 1 author, I agree to allow the corresponding author to serve as the primary correspondent with the editorial office, to review the edited typescript and proof, and to make decisions regarding release of information in the manuscript to the media, federal agencies, or both; or, if I am the only author, I will be the corresponding author and agree to serve in the roles described above.

- B. I have given final approval of the submitted manuscript.
- C. I have participated sufficiently in the work to take public responsibility for (check 1 of 2 below)
 - part of the content.
 - the whole content.

D. To qualify for authorship, you must check at least 1 box for each of the 3 categories of contributions listed below.

I have made substantial contributions to the intellectual content of the paper as described below.

- 1. (check at least 1 of the 3 below)
 - conception and design
 - acquisition of data
 - analysis and interpretation of data
- 2. (check at least 1 of 2 below)
 - drafting of the manuscript
 - critical revision of the manuscript for important intellectual content
- 3. (check at least 1 below)
 - statistical analysis
 - obtaining funding
 - administrative, technical, or material support
 - supervision
 - no additional contributions
 - other (specify) _____

Your Signature

Date Signed

- Participation that does **not** qualify for authorship includes:
 - Data gathering
 - Provision of financial or other support

Journal of Athletic Training 2007;42(3):403-408
© by the National Athletic Trainers' Association, Inc
www.journalofathletictraining.org

original research

Bone Mineral Density in Collegiate Female Athletes: Comparisons Among Sports

Lanay M. Mudd, MS; Willa Fornetti, DO, MS; James M. Pivarnik, PhD

Michigan State University, East Lansing, MI

Lanay M. Mudd, MS, contributed to conception and design; analysis and interpretation of the data; and drafting, critical revision, and final approval of the article. Willa Fornetti, DO, MS, contributed to conception and design; acquisition of the data; and drafting, critical revision, and final approval of the article. James M. Pivarnik, PhD, contributed to conception and design, acquisition and analysis and interpretation of the data, and critical revision and final approval of the article.

Any Limit on Number of Authors?



Image built from original here: <http://www.workingamerica.org/healthcarehustle/>



Azimuthal Charged-Particle Correlations and Possible Local Strong Parity Violation

B. I. Abelev,⁸ M. M. Aggarwal,²⁰ Z. Ahammed,⁴⁶ A. V. Alakhverdyants,¹⁶ B. D. Anderson,¹⁷ D. Arkhipkin,³ G. S. Averichev,¹⁶ J. Balewski,²¹ O. Barannikova,⁸ L. S. Barnby,² S. Baumgart,⁵¹ D. R. Beavis,³ R. Bellwied,⁴⁹ F. Benedosso,²⁶ M. J. Betancourt,²¹ R. R. Betts,⁸ A. Bhasin,¹⁵ A. K. Bhati,²⁹ H. Bichsel,⁴⁸ J. Bielcik,¹⁰ J. Bielcikova,¹¹ B. Biritz,⁶ L. C. Bland,³ I. Bnzarov,¹⁶ B. E. Bonner,³⁵ J. Bouchet,¹⁷ E. Braidot,²⁶ A. V. Brandin,²⁴ A. Bridgeman,¹ E. Bruna,⁵¹ S. Bueltmann,²⁸ T. P. Burton,² X. Z. Cai,³⁹ H. Caines,⁵¹ M. Calderón de la Barca Sánchez,⁵ O. Catu,⁵¹ D. Cebra,⁷ R. Cendejas,⁶ M. C. Cervantes,⁴¹ Z. Chajecki,²⁷ P. Chaloupka,¹¹ S. Chattopadhyay,⁴⁶ H. F. Chen,³⁷ J. H. Chen,¹⁷ J. Y. Chen,⁵⁰ J. Cheng,⁴³ M. Chemey,⁹ A. Chikanian,⁵¹ K. E. Choi,³³ W. Christie,³ P. Chung,¹¹ R. F. Clarke,⁴¹ M. J. M. Codrington,⁴¹ R. Corliss,²¹ T. M. Cormier,⁴⁹ M. R. Cosentino,³⁶ J. G. Cramer,⁴⁸ H. J. Crawford,⁴ D. Das,⁵ S. Dash,¹² M. Daugherty,⁴² L. C. De Silva,⁴⁹ T. G. Dedovich,¹⁶ M. DePhillips,³ A. A. Derevschikov,³¹ R. Derradi de Souza,⁷ L. Didenko,⁴¹ V. Dzhordzhadze,³ S. M. Dogra,¹⁵ X. Dong,²⁰ J. L. Drachenberg,⁴¹ J. E. Draper,⁵ J. C. Dunlop,³ M. R. Dutta Mazumdar,⁴⁶ L. G. Efimov,¹⁶ E. Elhalhuli,² M. Elnimr,⁴⁹ J. Engelage,⁴ G. Eppley,³⁵ B. Erasmus,⁴⁰ M. Estienne,⁴⁰ L. Eun,³⁰ P. Fachini,³ R. Fatemi,¹⁸ J. Fedorin,¹⁶ A. Feng,⁵⁰ P. Filip,¹⁶ E. Finch,⁵¹ V. Fine,³ Y. Fisyak,³ C. A. Gagliardi,⁴¹ D. R. Gangadharan,⁶ M. S. Ganti,⁴⁶ E. J. Garcia-Solis,⁸ A. Geromitsos,⁴⁰ F. Geurts,³⁵ V. Ghazikhanian,⁶ P. Ghosh,⁴⁶ Y. N. Gorbunov,⁹ A. Gordon,³ O. Grebenyuk,²⁰ D. Grosnick,⁴⁵ B. Grube,³³ S. M. Guertin,⁶ K. S. F. Guimarães,³⁶ A. Gupta,¹⁵ N. Gupta,¹⁵ W. Guryan,³ B. Haag,⁵ T. J. Hallman,³ A. Hamed,⁴¹ J. W. Harris,⁵¹ M. Heinz,⁵¹ S. Heppelmann,³⁰ A. Hirsch,¹² E. Hjort,²⁰ A. M. Hoffman,²¹ G. W. Hoffmann,⁴² D. J. Hofman,⁸ R. S. Hollis,⁸ H. Z. Huang,⁶ T. J. Humanic,²⁷ L. Huo,⁴¹ G. Igo,⁶ A. Iordanova,⁸ P. Jacobs,²⁰ W. W. Jacobs,¹⁴ P. Jakl,¹¹ C. Jena,¹² F. Jin,³⁹ C. L. Jones,²¹ P. G. Jones,² J. Joseph,¹⁷ E. G. Judd,⁴ S. Kabana,⁴⁰ K. Kajimoto,⁴² K. Kang,⁴³ J. Kapitan,¹¹ K. Kauder,⁸ D. Keane,¹⁷ A. Kechechyan,¹⁶ D. Kettler,⁴⁸ V. Yu. Khodyrev,³¹ D. P. Nikola,²⁰ J. Kiryluk,²⁰ A. Kisiel,⁴⁷ S. R. Klein,²⁰ A. G. Knospe,⁵¹ A. Kocoloski,² D. D. Koetke,⁴⁵ J. Konzer,³² M. Kopytine,¹⁷ I. Koralt,²⁸ W. Korsch,¹⁸ L. Kotchenda,²⁴ V. Kouchpil,¹¹ P. Kravtsov,²⁴ V. I. Kravtsov,³¹ K. Krueger,¹ M. Krus,¹⁰ L. Kumar,²⁹ P. Kurnadi,⁶ M. A. C. Lamont,³ J. M. Landgraf,³ S. LaPointe,⁴⁹ J. Lauret,³ A. Lebedev,³ R. Lednicky,¹⁶ C-H. Lee,³³ J. H. Lee,³ W. Leight,²¹ M. J. LeVine,³ C. Li,³⁷ N. Li,⁵⁰ Y. Li,⁴³ G. Lin,⁵¹ S. J. Lindenbaum,²⁵ M. A. Lisa,²⁷ F. Liu,⁵⁰ H. Liu,⁵ J. Liu,³ L. Liu,⁵⁰ T. Ljubicic,³ W. J. Llope,³⁵ R. S. Longacre,³ W. A. Love,³ Y. Lu,³⁷ T. Ludlum,³ G. L. Ma,³⁹ Y. G. Ma,³⁹ D. P. Mahapatra,¹² R. Majka,⁵¹ O. I. Mall,⁵ L. K. Mangotra,¹⁵ R. Manweiler,⁴⁵ S. Margetis,¹⁷ C. Markert,⁴² H. Masui,²⁰ H. S. Matis,²⁰ Yu. A. Matulenko,³¹ D. McDonald,³⁵ T. S. McShane,⁹ A. Meschanin,³¹ R. Milner,²¹ N. G. Minaev,³¹ S. Mioduszewski,⁴¹ A. Mischke,²⁶ B. Mohanty,⁴⁶ D. A. Morozov,³¹ M. G. Munhoz,³⁶ B. K. Nandi,¹³ C. Nattrass,⁵¹ T. K. Nayak,⁴⁶ J. M. Nelson,² P. K. Netrakanti,³² M. J. Ng,⁴ L. V. Nogach,³¹ S. B. Nurushev,³¹ G. Odyniec,²⁰ A. Ogawa,³ H. Okada,³ V. Okorokov,²⁴ D. Olson,²⁰ M. Pachr,¹⁰ B. S. Page,¹⁴ S. K. Pal,⁴⁶ Y. Pandit,¹⁷ Y. Panebratsev,¹⁶ T. Pawlak,⁴⁷ T. Peitzmann,²⁶ V. Perevozchikov,³ C. Perkins,⁴ W. Peryt,⁴⁷ S. C. Phatak,¹² P. Pile,³ M. Planinic,⁵² M. A. Ploskon,²⁰ J. Pluta,⁴⁷ D. Plyku,²⁸ N. Poljak,⁵² A. M. Poskanzer,²⁰ B. V. K. S. Potukuchi,¹⁵ D. Prindle,⁴⁸ C. Pruneau,⁴⁹ N. K. Pruthi,²⁹ P. R. Pujahari,¹³ J. Putschke,⁵¹ R. Raniwala,³⁴ S. Raniwala,³⁴ R. L. Ray,⁴² R. Redwine,²¹ R. Reed,⁵ A. Ridiger,²⁴ H. G. Ritter,²⁰ J. B. Roberts,³⁵ O. V. Rogachevskiy,¹⁶ J. L. Romero,⁵ A. Rose,²⁰ C. Roy,⁴⁰ L. Ruan,³ M. J. Russcher,²⁶ R. Sahoo,⁴⁰ S. Sakai,⁶ I. Sakrejda,²⁰ T. Sakuma,²¹ S. Salur,²⁰ J. Sandweiss,⁵¹ J. Schambach,⁴² R. P. Scharenberg,³² N. Schmitz,²² J. Seele,²¹ J. Seger,⁹ I. Selyuzhenkov,¹⁴ Y. Semertzidis,³ P. Seyboth,²² E. Shafaliev,¹⁶ M. Shao,³⁷ M. Sharma,⁴⁹ S. S. Shi,⁵⁰ X-H. Shi,³⁹ E. P. Sichtermann,²⁰ F. Simon,²² R. N. Singaraju,⁴⁶ M. J. Skoby,³² N. Smimov,⁵¹ P. Sorensen,³ J. Sowinski,¹⁴ H. M. Spinka,¹ B. Srivastava,³² T. D. S. Stanislaus,⁴⁵ D. Staszak,⁶ M. Strikhanov,²⁴ B. Stringfellow,³² A. A. P. Suaide,³⁶ M. C. Suarez,⁸ N. L. Subba,¹⁷ M. Sumera,¹¹ X. M. Sun,²⁰ Y. Sun,³⁷ Z. Sun,¹⁹ B. Surrow,²¹ T. J. M. Symons,²⁰ A. Szanté de Toledo,³⁶ J. Takahashi,⁷ A. H. Tang,³ Z. Tang,³⁷ L. H. Tarini,⁴⁹ T. Tarnowski,²³ D. Thein,⁴² J. H. Thomas,²⁰ J. Tian,³⁹ A. R. Timmins,⁴⁹ S. Timoshenko,²⁴ D. Tlusty,¹¹ M. Tokarev,¹⁶ V. N. Tram,²⁰ S. Trentalange,⁶ R. E. Tribble,⁴¹ O. D. Tsai,⁶ J. Ulery,³² T. Ullrich,³ D. G. Underwood,²³ C. Van Buren,³ G. van Nieuwenhuizen,²¹ J. A. Vanfossen, Jr.,¹⁷ R. Varma,¹³ G. M. S. Vasconcelos,⁷ A. N. Vasiliev,³¹ F. Videbaek,³ Y. P. Viyog,⁴⁶ S. Vokal,¹⁶ S. A. Voloshin,⁴⁹ M. Wada,⁴² M. Walker,²¹ F. Wang,³² G. Wang,⁶ H. Wang,²³ J. S. Wang,¹⁹ Q. Wang,³² X. Wang,⁴³ X. L. Wang,³⁷ Y. Wang,⁴³ G. Webb,¹⁸ J. C. Webb,⁴⁵ G. D. Westfall,²³ C. Whitten, Jr.,⁶ H. Wieman,²⁰ S. W. Wissink,¹⁴ R. Witt,⁴⁴ Y. Wu,⁵⁰ W. Xie,³² N. Xu,²⁰ Q. H. Xu,³⁸ Y. Xu,³⁷ Z. Xu,³ Y. Yang,¹⁹ P. Yepes,⁵⁵ K. Yip,³ I-K. Yoo,³³ Q. Yue,⁴³ M. Zawisza,⁴⁷ H. Zbroszczyk,⁴⁷ W. Zhan,¹⁹ S. Zhang,³⁹ W. M. Zhang,¹⁷ X. P. Zhang,²⁰ Y. Zhang,²⁰ Z. P. Zhang,³⁷ Y. Zhao,³⁷ C. Zhong,³⁹ J. Zhou,³⁵ X. Zhu,⁴³ R. Zoukameev,¹⁶ Y. Zoukarnieva,¹⁶ and J. X. Zuo³⁹

International Committee of Medical Journal Editors (ICMJE)

- <http://www.icmje.org/>
- First met in Vancouver in 1978
- Later became the ICMJE
- Developed a number of statements and standards re: manuscript submission
- Most recently revised in Oct, 2014
- One issue is authorship

- According to ICMJE, authorship should be based on:
 - 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data
 - 2) drafting the article or revising it critically for important intellectual content
 - 3) final approval of the version to be published
 - 4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

*Authors should meet conditions 1,2,3 and 4

Additional info

- Acquisition of funding, collection of data, or general supervision of the research group, alone, *does not* justify authorship.
- Each author should have participated sufficiently in the work to take public responsibility for ***appropriate*** portions of the content.

What does MSU say?

Michigan State University Guidelines on Authorship

Approved by the Council of Research Deans, October 25, 2012

1. **Authorship:** A person shall qualify as an Author, if and only if the following conditions are satisfied::

- Participation in conception and design of the creative work, study, review, analysis
or interpretation of any data.
- Participation in the drafting of the creative work or manuscript or in the editing of the creative work or manuscript.
- Final approval of the version of the creative work or manuscript to be published.
- Ability to explain and defend appropriate portions of the work or study in public or scholarly settings.



Philip Greenland is the Harry W. Dingman Professor of Preventive Medicine and Medicine at the Northwestern University Feinberg School of Medicine, Chicago, IL. He is a former editor of the *Archives of Internal Medicine*.



Phil B. Fontanarosa is executive editor of the *Journal of the American Medical Association* and Adjunct Professor of Emergency Medicine and Preventive Medicine at the Northwestern University Feinberg School of Medicine, Chicago, IL.

Ending Honorary Authorship

CREDIT FOR SCIENTIFIC RESEARCH CONTRIBUTIONS MUST BE CLEARLY AND APPROPRIATELY ASSIGNED at the time of publication. This task has become increasingly complicated because of the number of different laboratories and coauthors involved in many studies. The good news is that academic institutions, funders, and publishers are exploring new ways to clarify attribution,* and many publishers now require disclosure of specific contributions for scientific authorship. As part of this effort, it is critical that the problem of honorary authorship be effectively addressed. According to a recent report, honorary authors were attached to 25% of research reports, 15% of review articles, and 11% of editorials published in six major medical journals in 2008.† It is time to end this practice.

A true author is someone who has made substantive intellectual contributions to a study and is responsible for a component of the work. Honorary authorship violates this central principle. Why then is it so frequent? In some cases, honorary authorship amounts to "coercive authorship," in which a senior person informs a junior colleague that the senior person must be listed as an author, even though she/he did not contribute substantially—or at all—to the work. In other cases, the principal investigator may add the name of a prominent scientist in the field as a guest author in an attempt to boost the paper's chance of publication. Both types of behavior have fraudulent aspects, distorting the ethical culture that is central to a healthy academic environment.

To discourage honorary authorship and ensure appropriate accountability for published results, many journals have updated their policies on authorship. For some (including *Science*), all authors must formally agree to be listed as authors, specify their contributions to the manuscript, and certify that they approve of its content and submission to the journal. But scientific journals could go even further by adding a statement on authorship forms that reminds authors of their accountability in the event of challenges to the veracity or integrity of the work, such as "By signing this statement, I acknowledge that I take credit for the content of the published work. I also acknowledge that I will take responsibility for the work if questions arise in the future as to its authenticity and credibility." Such a statement would serve as a firm reminder that being inappropriately listed as an author has negative consequences if the results are challenged or retracted.

Research institutions should develop and promulgate clear statements in their research policies about the importance of upholding ethical standards of authorship. For example, Washington University in St. Louis‡ defines both guest and gift authorship as research misconduct, whereby "guest (honorary, courtesy, or prestige) authorship is defined as granting authorship out of appreciation or respect for an individual, or in the belief that expert standing of the guest will increase the likelihood of publication, credibility, or status of the work" and "gift authorship is credit, offered from a sense of obligation, tribute, or dependence, within the context of an anticipated benefit, to an individual who has not contributed to the work." Each institution should also specify to whom concerns should be directed, without fear of retribution, when an author feels coerced to include an inappropriate author.

It is incumbent on more-senior coauthors to assist in educating their colleagues about the proper standards for authorship. But all scientists should take a stand against coercive authorship and refuse to comply with such behavior. In this way, senior faculty and mentors will serve as role models of best practices, reinforcing for more-junior investigators the importance of ensuring appropriate authorship. Honorary authorship must no longer be tolerated. Concerted efforts by institutions, authors, and journals are needed to put an end to this fraudulent and unethical practice.

— Philip Greenland and Phil B. Fontanarosa

10.1126/science.1224988

*http://projects.iq.harvard.edu/attribution_workshop. †J. S. Wislar et al., *Br. Med. J.* 343, 66128 (2011).
‡<http://wustl.edu/policies/authorship.html>.

Quit whining, it's not a big deal



Dr. Thereza Imanishi-Kari



Dr. David Baltimore



Baltimore, David

Baltimore, David (bôl'timôr, -mur) [key], 1938–, American microbiologist, b. New York City, Ph.D. Rockefeller Univ., 1964. He conducted (1965–68) virology research at the Salk Institute before becoming a professor at Massachusetts Institute of Technology in 1972. In 1970 he and his wife Alice Huang discovered a virus caused by an enzyme that could transcribe DNA into RNA. He shared the 1975 Nobel Prize in Physiology or Medicine with Renato Dulbecco and Howard Temin for his study on the connections between viruses and cancer.

Appointed president of Rockefeller Univ. in 1990, he resigned the next year after a scientific fraud scandal. A paper he coauthored was said to contain fraudulent data from another author, Dr. Thereza Imanishi-Kari, and Baltimore was criticized for his vehement defense of the paper despite the evidence. In 1996, an appeals panel overturned the verdict of the original investigating office, the federal Office of Scientific Integrity (now the Office of Research Integrity), and Baltimore and Imanishi-Kari were exonerated. In 1997 Baltimore was appointed president of the California Institute of Technology.

See D. J. Kevles, *The Baltimore Case: A Trial of Politics, Science, and Character* (1998).

The Columbia Electronic Encyclopedia, 6th ed.

Contributorship

- All contributors who do not meet the criteria for authorship should be listed in an acknowledgments section. Examples of those who might be acknowledged include a person who provided purely technical help, writing assistance, or a department chair who provided only general support.

Question.....

- Does (or should) being a member of a thesis or dissertation committee automatically qualify one for authorship?

Order, Order



Who Cares?

- Compendium of physical activities: classification of energy costs of human physical activities
- *Med Sci Sports Exerc* 25: 71-80, 1993
- Over 3800 Citations!!!
- Ainsworth et al.
- Ainsworth, Haskell, Leon, Jacobs, Montoye, Sallis, Paffenbarger

American Psychological Association (APA)

- According to the 6th edition of the APA manual, "The names of the authors should appear **in the order of their contributions**, centered between the side margins."

Authorship Order

- The group should jointly make decisions about contributors/authors before submitting the manuscript for publication. The corresponding author/guarantor should be prepared to explain the presence and order of these individuals. **It is not the role of editors to make authorship/contributorship decisions or to arbitrate conflicts related to authorship.**
- (ICMJE, 2008)

Authorship Order

- No proposal for more informative and standardized systems for ordering the names of authors has been universally accepted. (Rennie, 1994)
- While the significance of a particular order may be understood in a given setting, order of authorship has no generally agreed upon meaning. (Harvard Medical School, 1999)

- Deciding the order of authors on research papers is a recognised problem. Currently, authorship order cannot be interpreted by readers and editors. The last position often carries more status. In some papers the senior investigator is named last, in others it is the head of the laboratory or department, and in others it is the person who contributed least. (BMJ, 1997)

- The order of authors is a collective decision of the authors or study group. This policy does not address questions or disputes regarding the order of authorship on publications. **It is not possible for the University to define the order of authorship.** In conjunction with the lead author, co-authors should discuss authorship order at the onset of the project and revise their decision as needed. **All authors must work together to make these informed judgments.**
 - WUSTL, Compliance and Policies, 2009

What does MSU say?

3. Lead Author and Order of Authors: The Lead author is defined as the person who leads a research/scholarly effort or creative work and makes a major contribution to a multi-authored work. The Lead author is also responsible for gathering the appropriate consents necessary (animal, human use) and for validating the integrity of the work.

The Lead author takes the lead of discussing the contributions, recognition and order of all authors that participate in the study. All authors, regardless of position, have a voice in this discussion. *Ideally, author arrangement is agreed to proactively, formally, and in writing prior to the initiation of the study.* A sample agreement that allows for formal recognition and agreement on authorship can be found as an appendix to this policy. As the study evolves, agreements regarding authorship may need to be further discussed. Most journals and other scholarly outlets do not include statements on author order, so the Lead Author should guide this process and adhere to the norm of the discipline.

Self-Plagiarism



Self-Plagiarism

- Text Recycling
- Copyright Infringement
- Partitioning (salami slicing)
- Redundant Publication

What is a redundant publication?



What is a redundant publication?

- According to the ICMJE:

Redundant (or duplicate) publication is publication of a paper that ***overlaps*** ***substantially*** with one already published in print or electronic media.

What's the big deal?

- Duplicate publication of original research is particularly problematic, since it can result in inadvertent double counting or inappropriate weighting of the results of a single study, which distorts the available evidence.

How to prevent redundancy?

- Responsibility of author(s) to let the Journal Editor know that there may be an issue.
- Complete disclosure should be made up front when the manuscript is submitted.

- When submitting a paper, the author must always make a complete statement to the editor about all submissions and previous reports (including meeting presentations and posting of results in registries) that might be regarded as redundant or duplicate publication. **The author must alert the editor if the manuscript includes subjects about which the authors have published a previous report or have submitted a related report to another publication.** Any such report must be referred to and referenced in the new paper. Copies of such material should be included with the submitted manuscript to help the editor decide how to handle the matter.
 - ICMJE, 2008

Related Question

- Who “owns” the data collected by a student for his/her dissertation at MSU?



Research Data:

Management, Control, and Access

- Both the University and the PI have responsibilities and rights concerning access to, use of, and maintenance of original research data. Except where precluded by the specific terms of sponsorship or other agreements, tangible research property, including scientific data and other records of research conducted under the auspices of Michigan State University, belongs to Michigan State University. **The PI should be responsible for maintenance and retention of research data.**

Research Data: Management, Control, and Access

- The **PI** is the signatory person who has **scholarly responsibility** for the conduct of the proposed research.
- When individuals involved in research projects at Michigan State University leave the University, they may take copies of research data for projects on which they have worked. **The PI must, however, retain original data at Michigan State University.**

Bottom Line (IMHO)

- To determine authorship rules
 - First, check with the journal
 - Next, check MSU guidelines
- PI or advisor has final say on where to submit and authorship order
- If in doubt, feel free to check with me

So what's the answer?



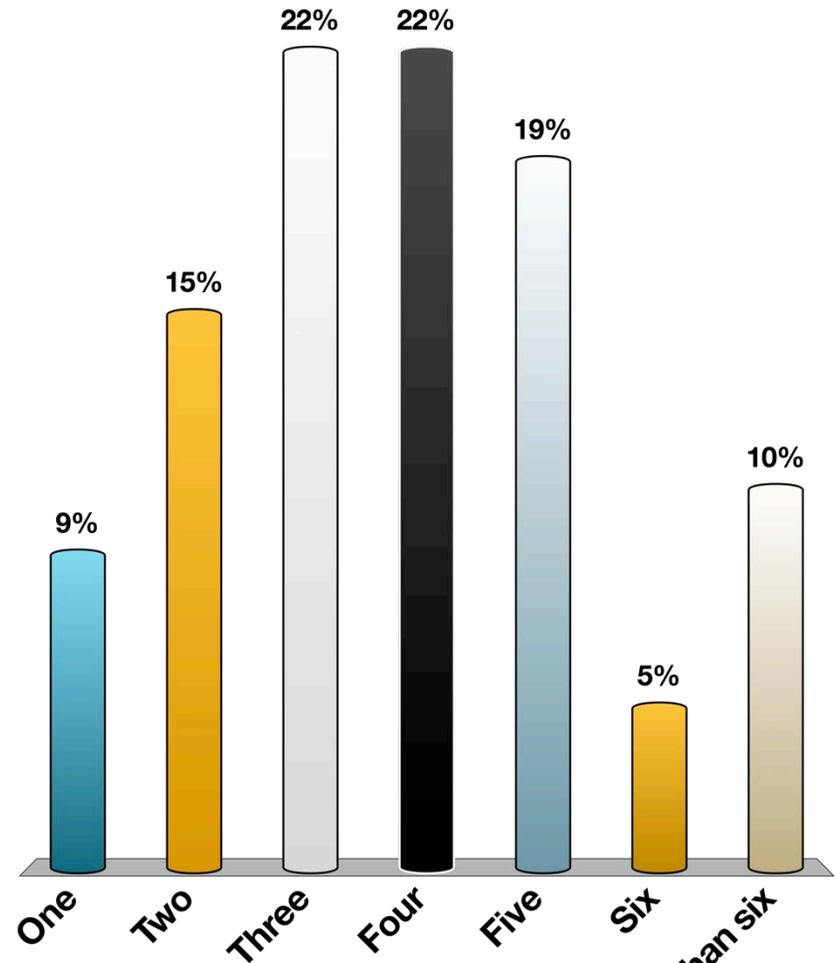
Thank you...Any Questions?





How many RCR Workshops have you attended, including tonight's?

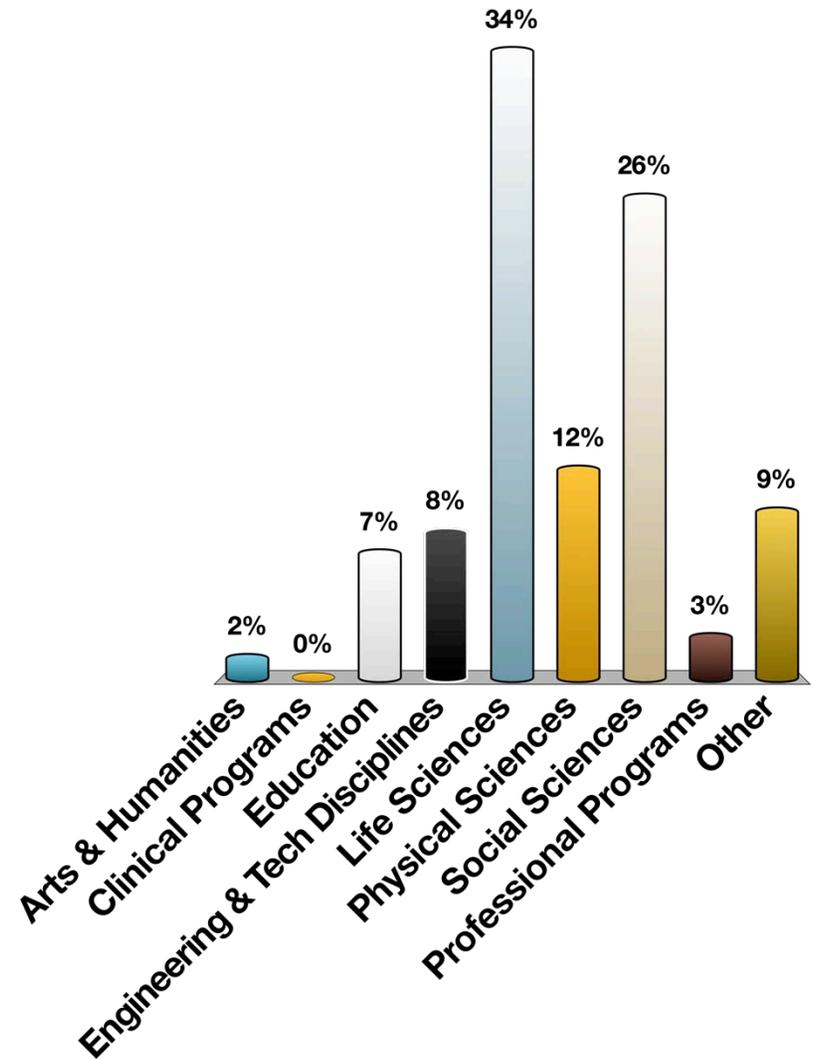
1. One
2. Two
3. Three
4. Four
5. Five
6. Six
7. More than six



Which of the following describes best your disciplinary academic affiliation



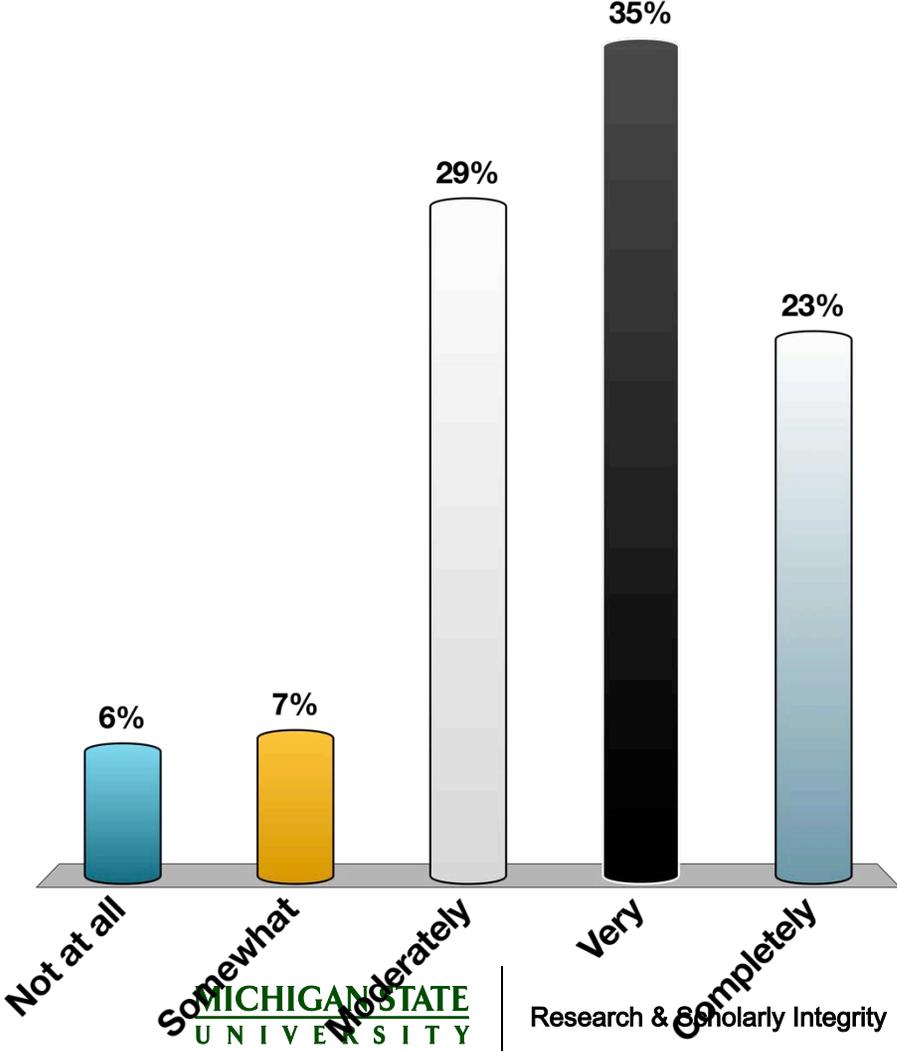
1. Arts & Humanities
2. Clinical Programs
3. Education
4. Engineering & Tech Disciplines
5. Life Sciences
6. Physical Sciences
7. Social Sciences
8. Professional Programs
9. Other



I understand and could explain what constitutes Research Misconduct at MSU.



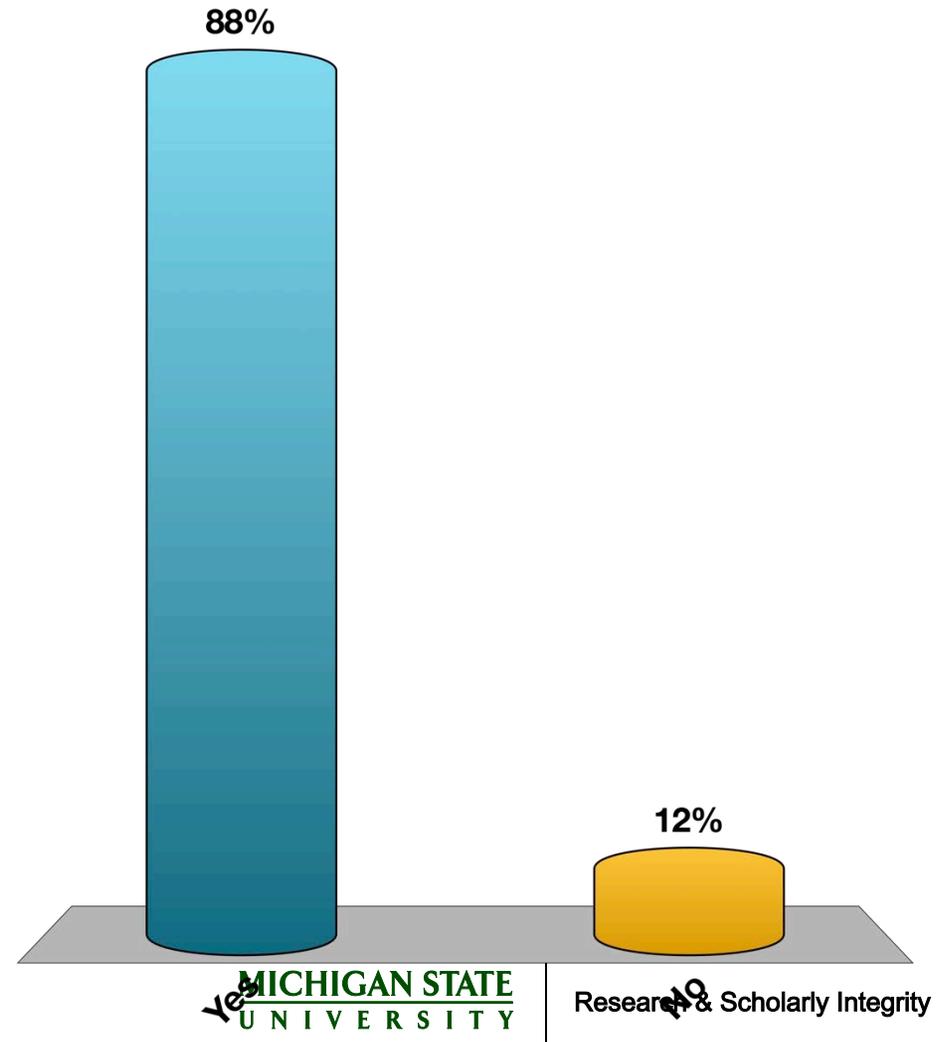
- 1. Not at all
- 2. Somewhat
- 3. Moderately
- 4. Very
- 5. Completely



Do you feel that you have an obligation to report acts by others that you observe & know to violate University policies or Research Integrity Guidelines?



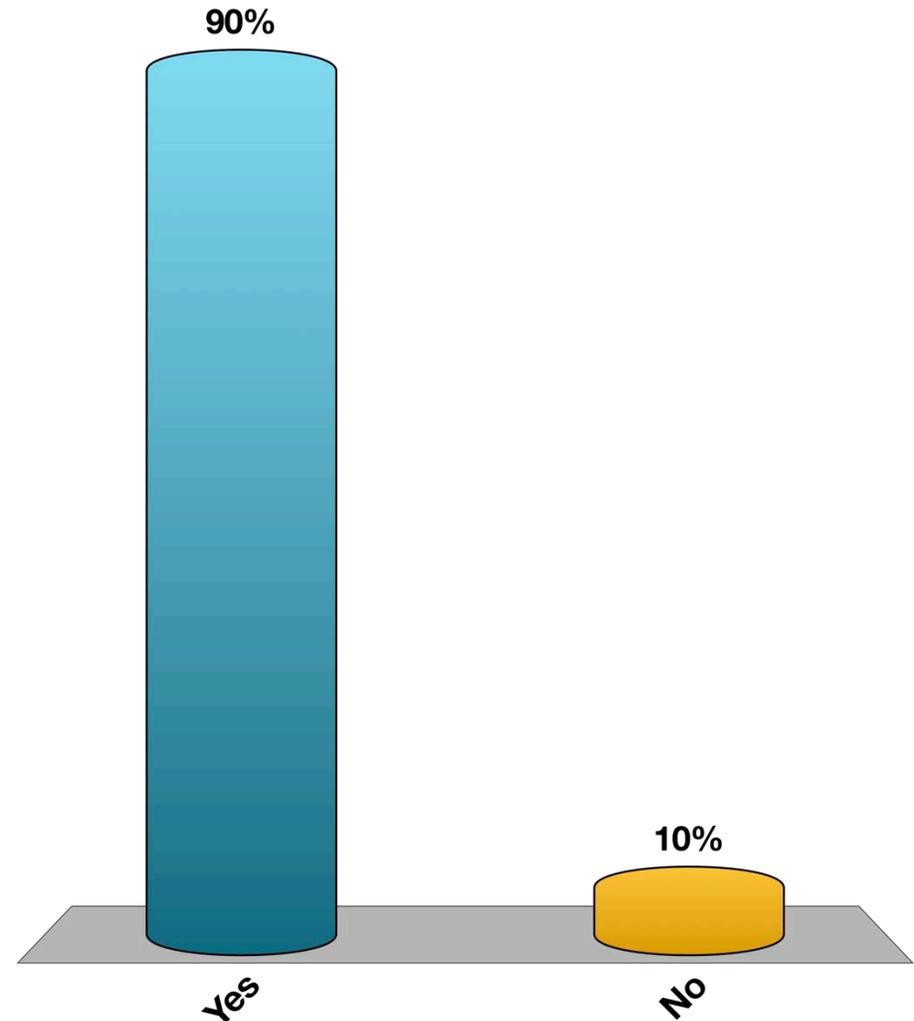
1. Yes
2. No



Would you report violations of academic integrity if it could be done anonymously?



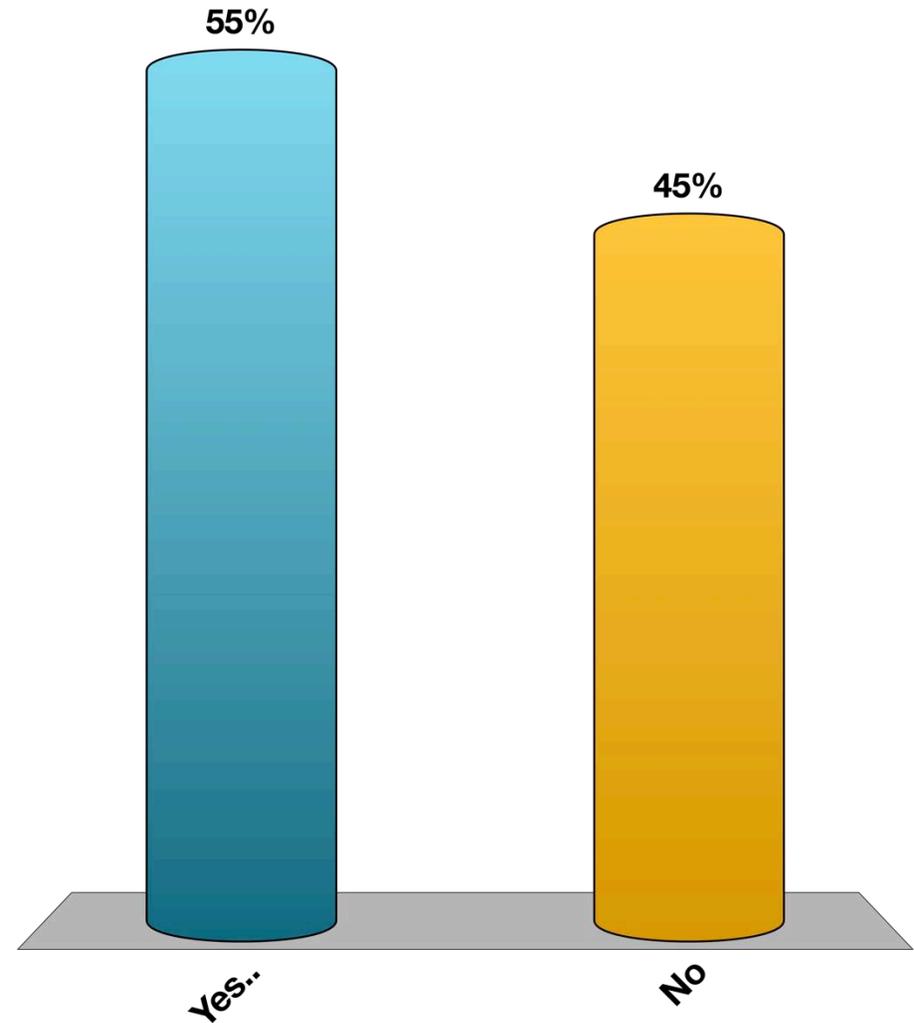
1. Yes
2. No



Would you report violations of academic integrity if it could NOT be done anonymously?



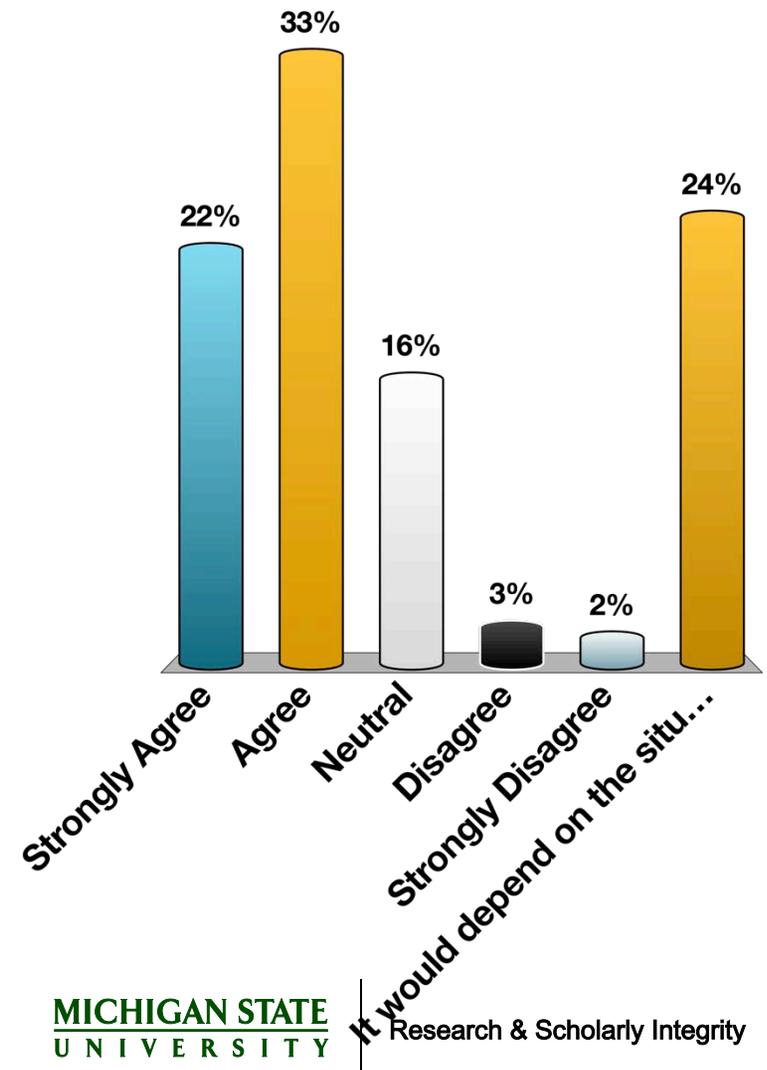
1. Yes..
2. No



I would report a fellow student to the RIO if I believed s/he committed research misconduct.



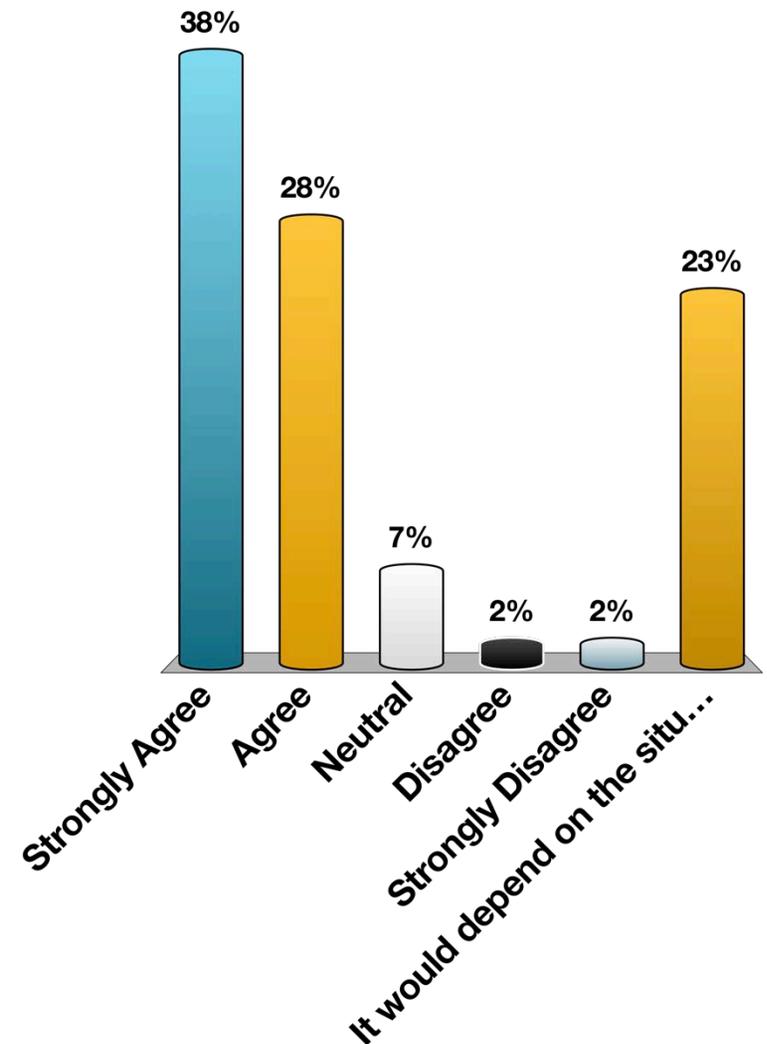
1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly Disagree
6. It would depend on the situation



I would report a faculty member who was not my major professor to the RIO if I believed s/he committed research misconduct.



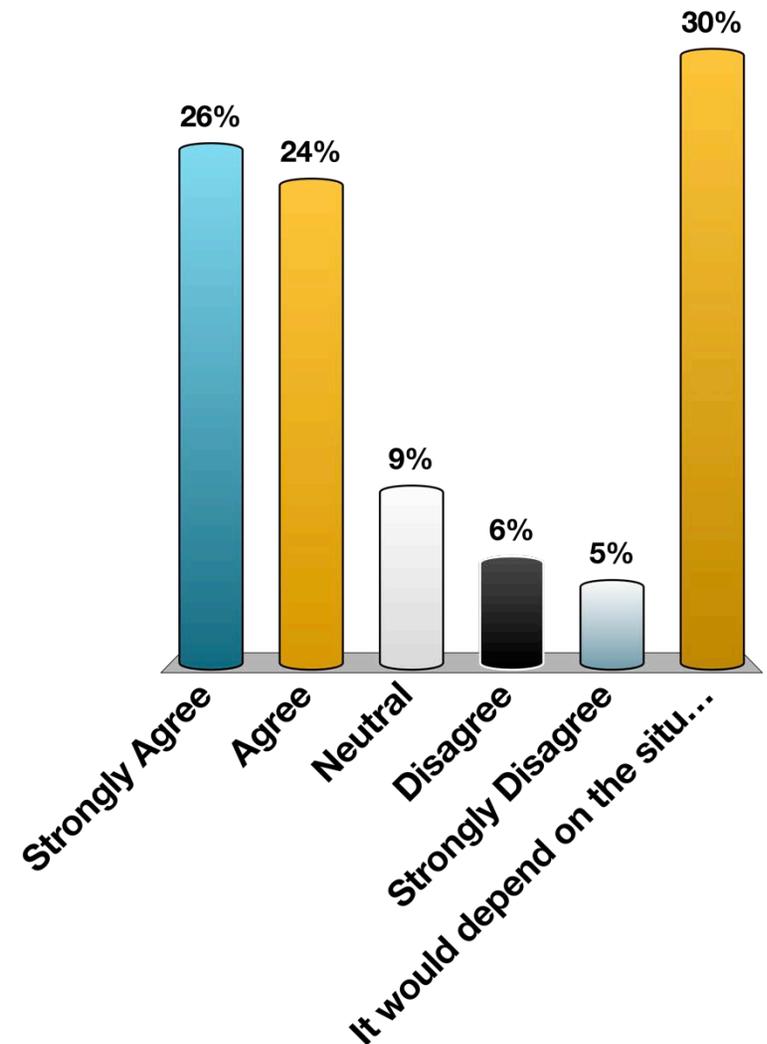
1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly Disagree
6. It would depend on the situation



I would report my major professor to the RIO if I believed s/he committed research misconduct.



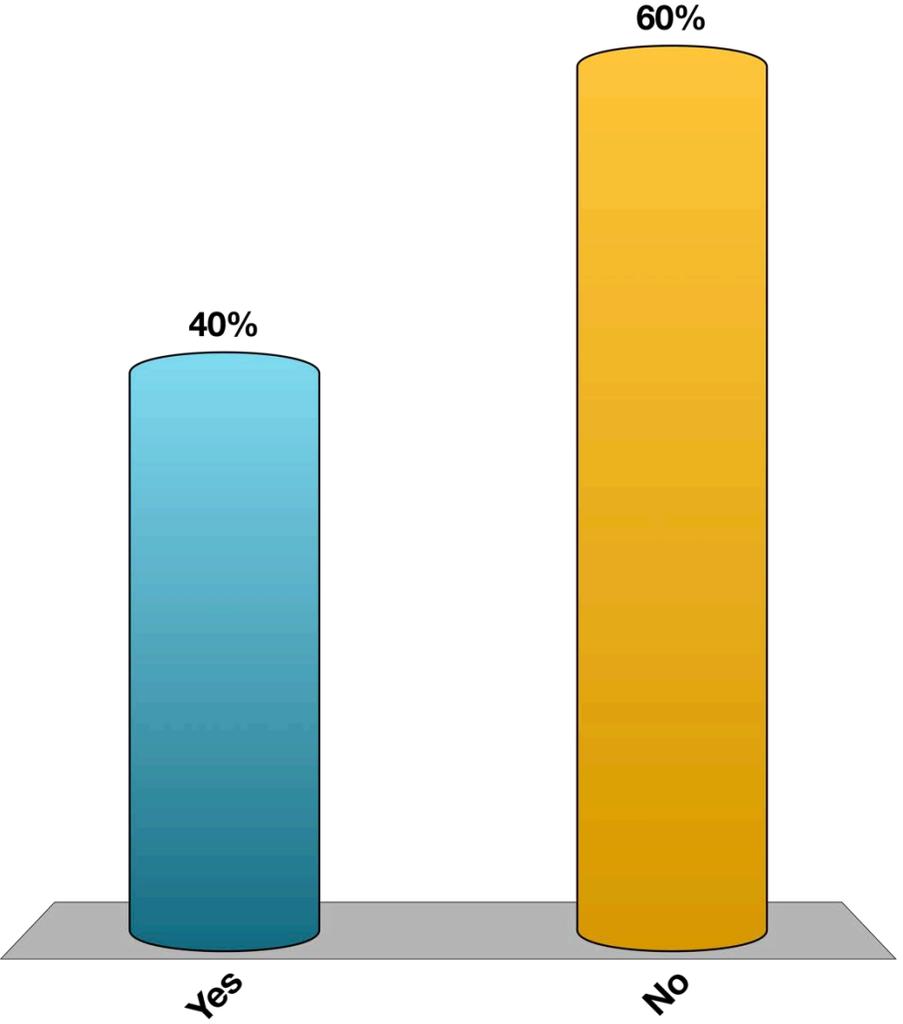
1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly Disagree
6. It would depend on the situation



Do you have direct knowledge of situations at MSU that you believe would constitute Research Misconduct based on tonight's explanations?



- 1. Yes
- 2. No



LAST SESSION OF THE YEAR IN MARCH!!

Rigor and Reproducibility,
March 1, 2018