

Biometrics

COMP 388-002/488-002 Computer Science Topics

Daniel Moreira
Fall 2026



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UNIVERSITY CHICAGO

Today we will...

Get to know what is ahead of us
in the course.

Welcome

COMP 388-002/488-002 Computer Science Topics Biometrics

Daniel Moreira

Contact: dmoreira1@luc.edu and Teams

Office: Doyle Center 310

Alisa Samakhval (TA)

asamakhval@luc.edu



Course Hours

Lectures: TUE and THR, 4:15 to 5:30 PM, Mundelein Center 519

Office Hours: TUE, MON, and WED evenings, Doyle Center 310 or Zoom,
by appointment (<https://calendly.com/danielmoreira/fall-2026-office-hours>)

Communication

Sakai: <https://sakai.luc.edu/x/wWJz6k>

Webpage: <https://danielmoreira.github.io/teaching/biometrics-aut26/>

About me

Computer Scientist

PhD from the University of Campinas (Brazil)

Theme: Sensitive-Video Analysis

Loyola University Chicago

Assistant Professor

Research

Media Forensics, Biometrics, Machine Learning, Computer Vision

Webpage: <https://danielmoreira.github.io>

(see following slides)





Media Forensics

<https://danielmoreira.github.io/project/medifor/>

The Problem

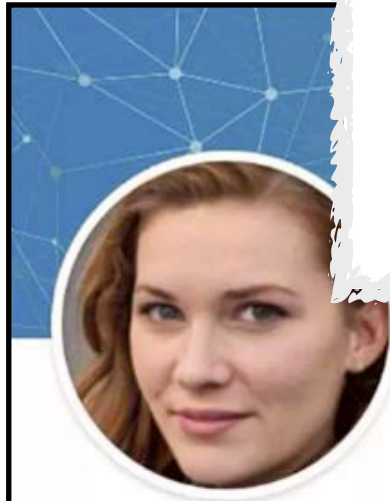
c|net

SCI-TECH

Spy reportedly used AI-generated photo to connect with targets on LinkedIn

A fake account had links to politically connected figures in Washington, the Associated Press reports.

BY STEVEN MUSIL | JUNE 13, 2019 5:13 PM PDT

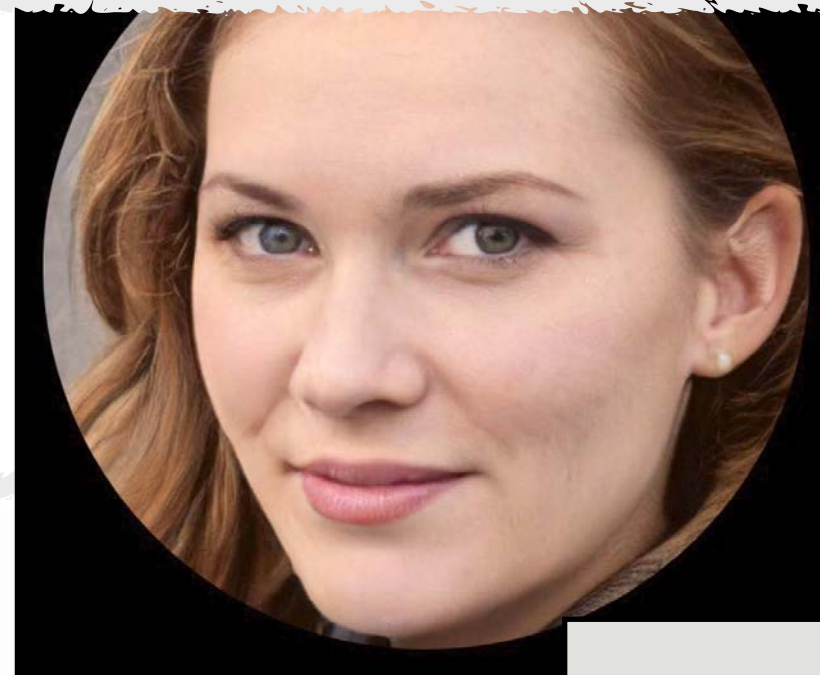


Connect

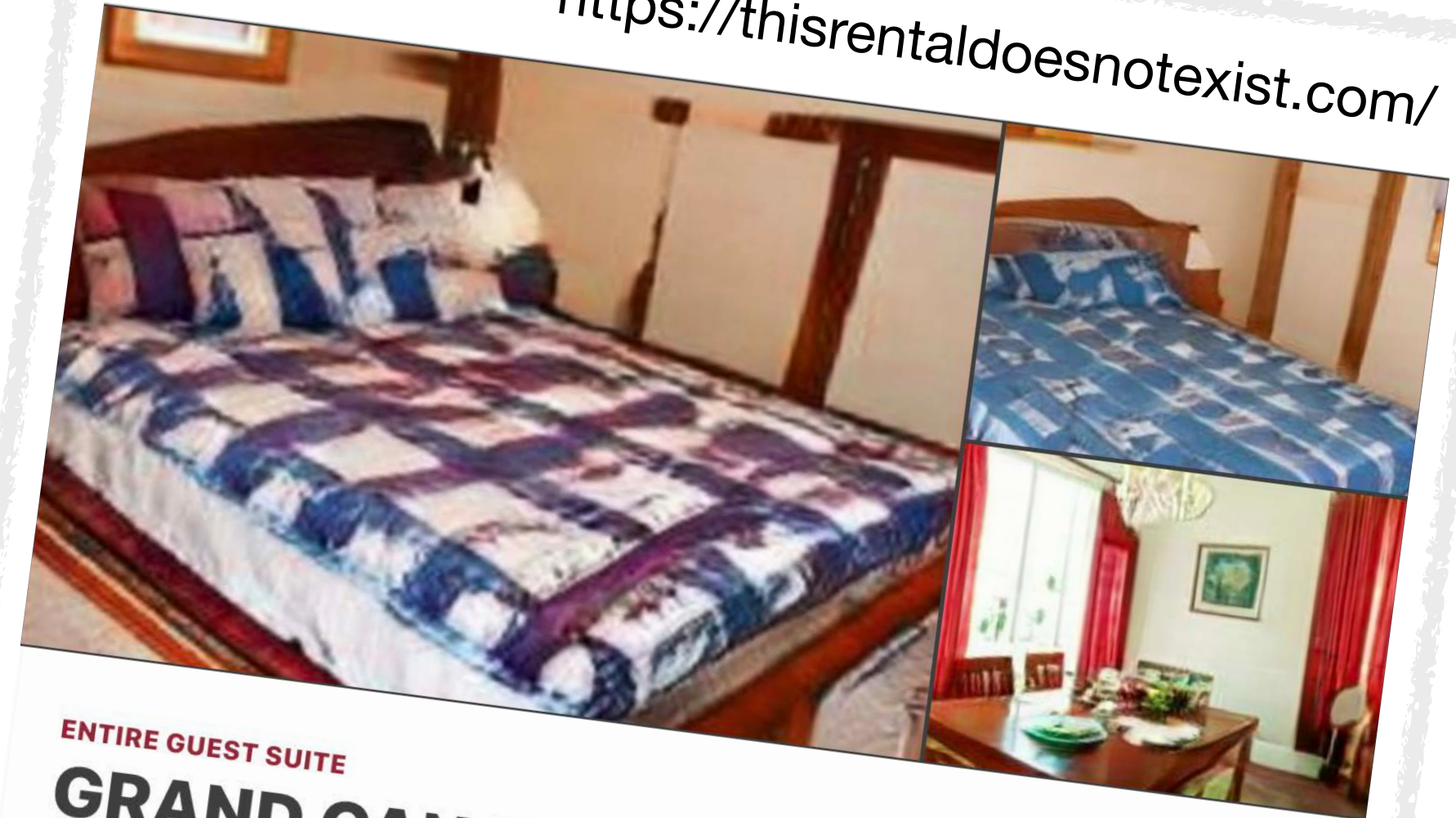
Katie Jones

Russia and Eurasia Fellow

Center for Strategic and International Studies (CSIS) ·
University of Michigan College of Literature, Science...
Washington · 49 connections



**Crafting new images with
photo manipulation.**



ENTIRE GUEST SUITE

**GRAND CANAL TOUR VIEW 3 BED 1/2
BATH**

<https://thisrentaldoesnotexist.com/>



<https://www.youtube.com/watch?v=p7-B8S734T4>





The Notorious B.I.G.
NY scene rapper

HANGING OUT?

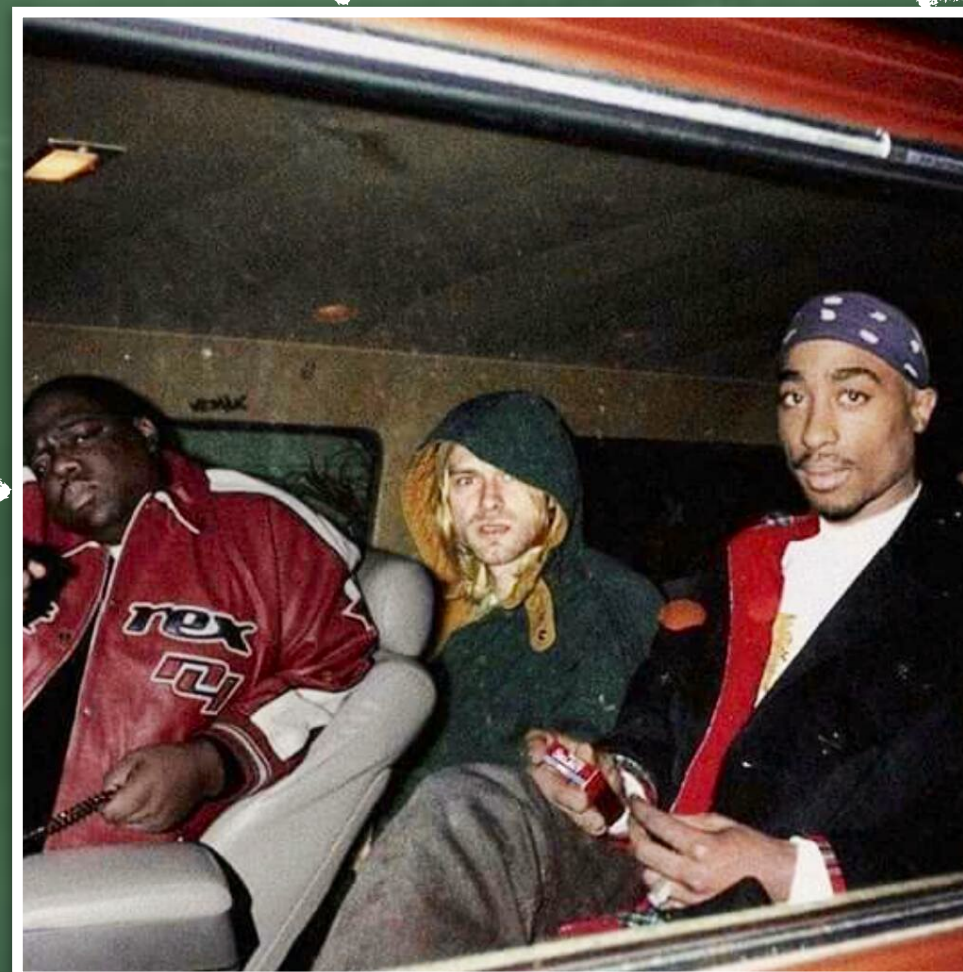
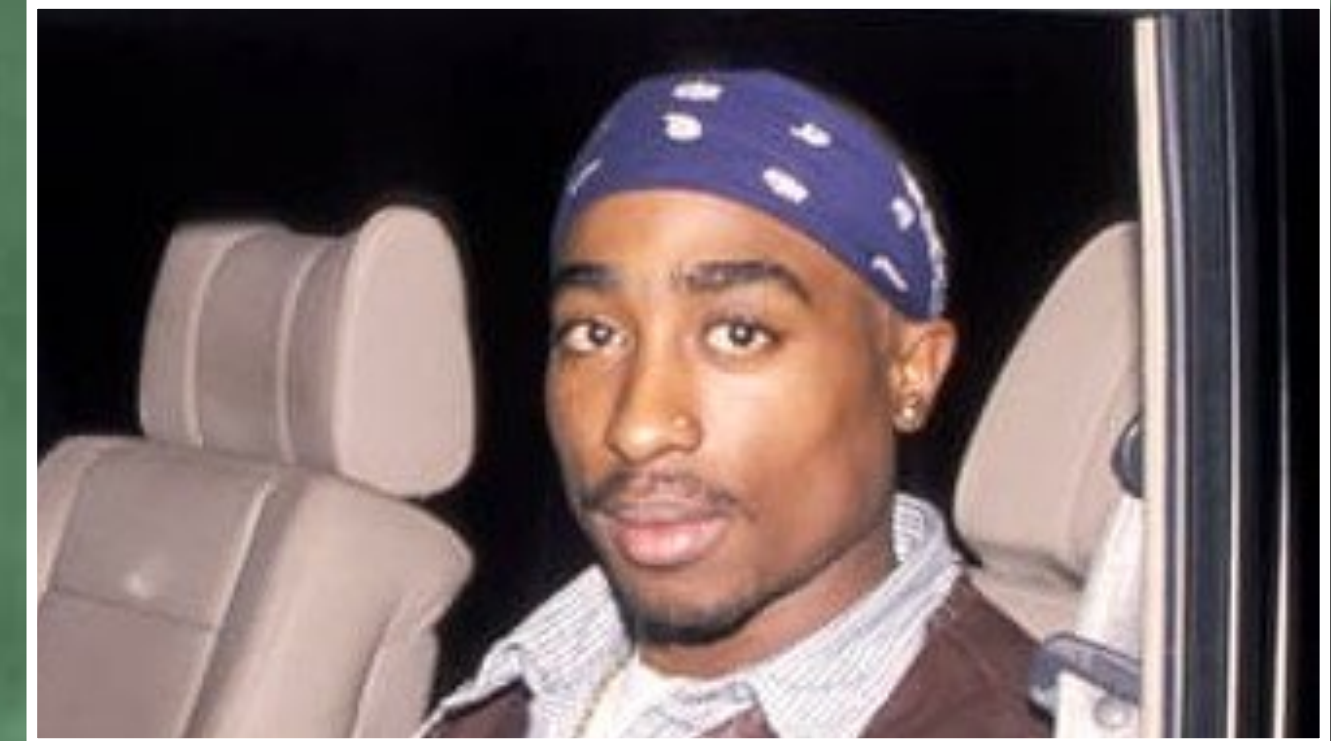
Kurt Cobain
Grunge scene musician





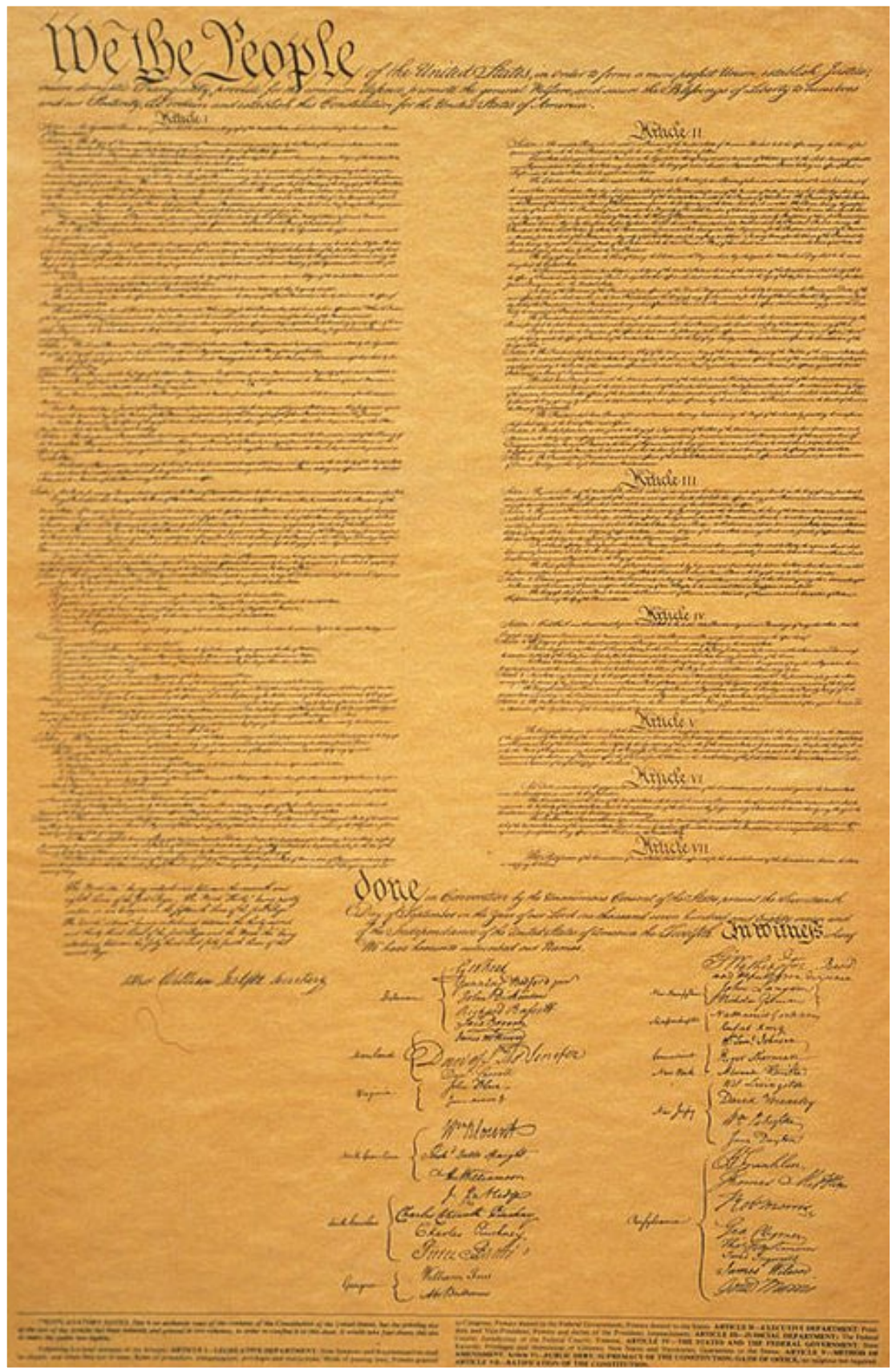
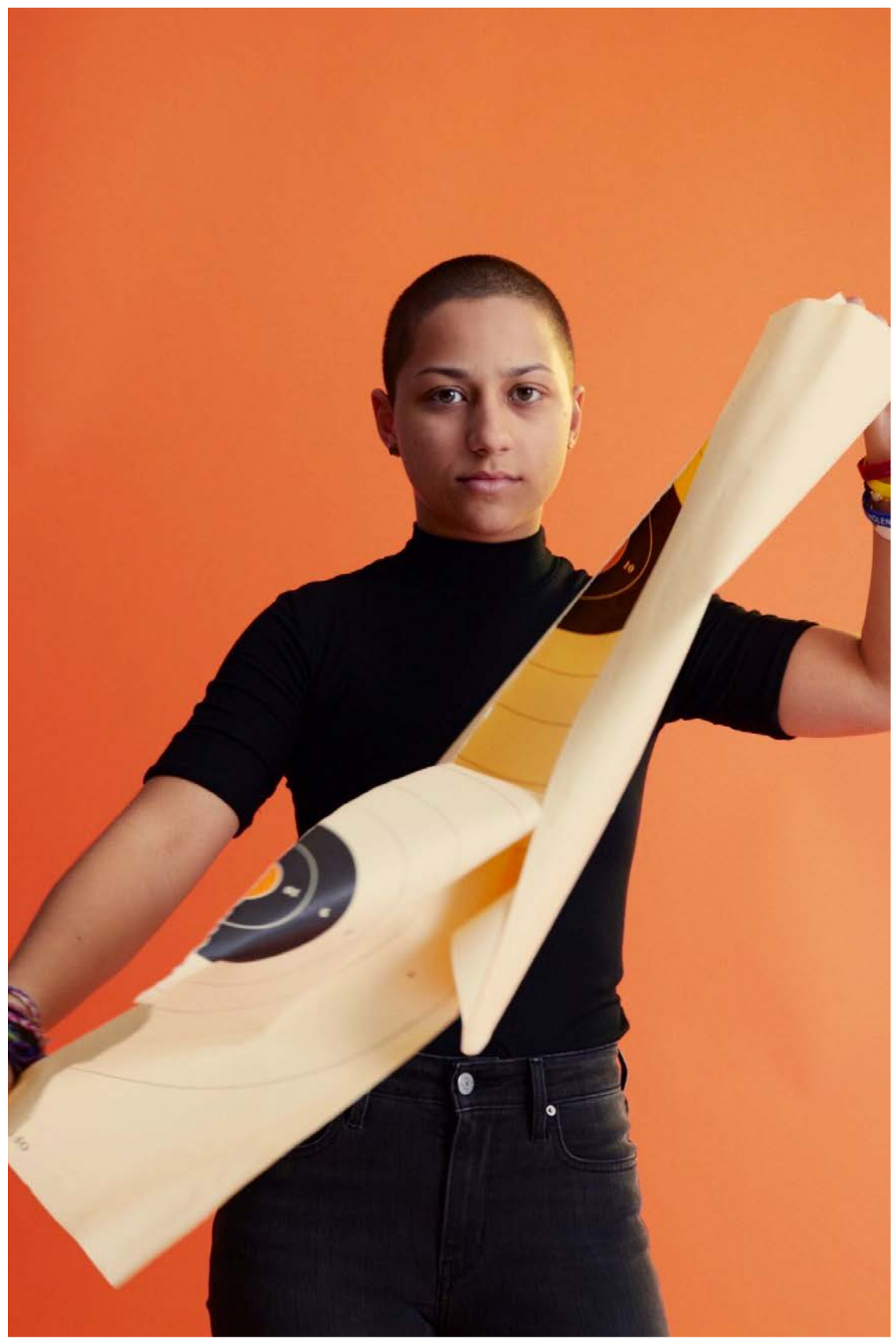
Tupac Shakur
LA scene rapper



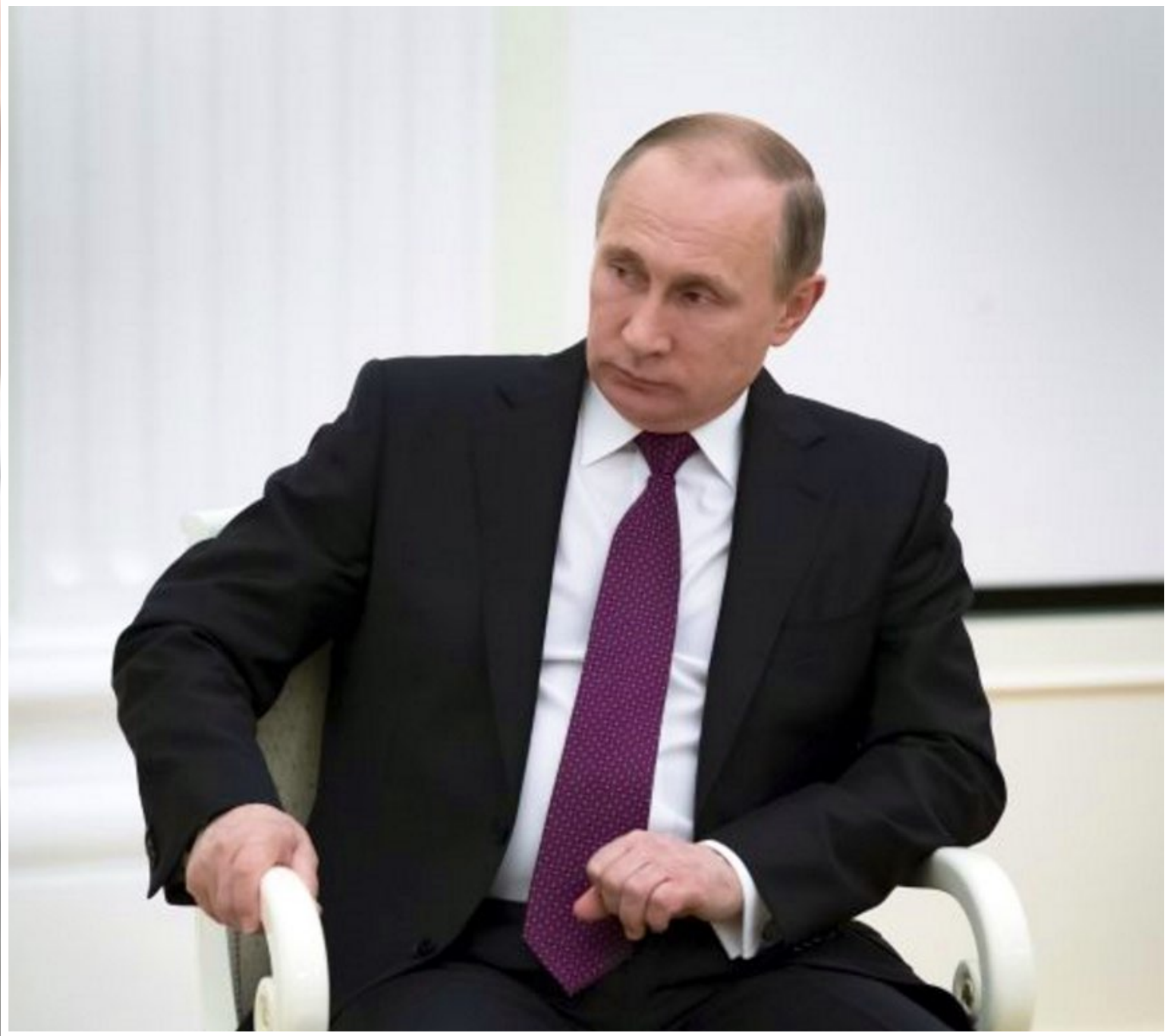


Provenance
Graph









Russian Federation

Turkey

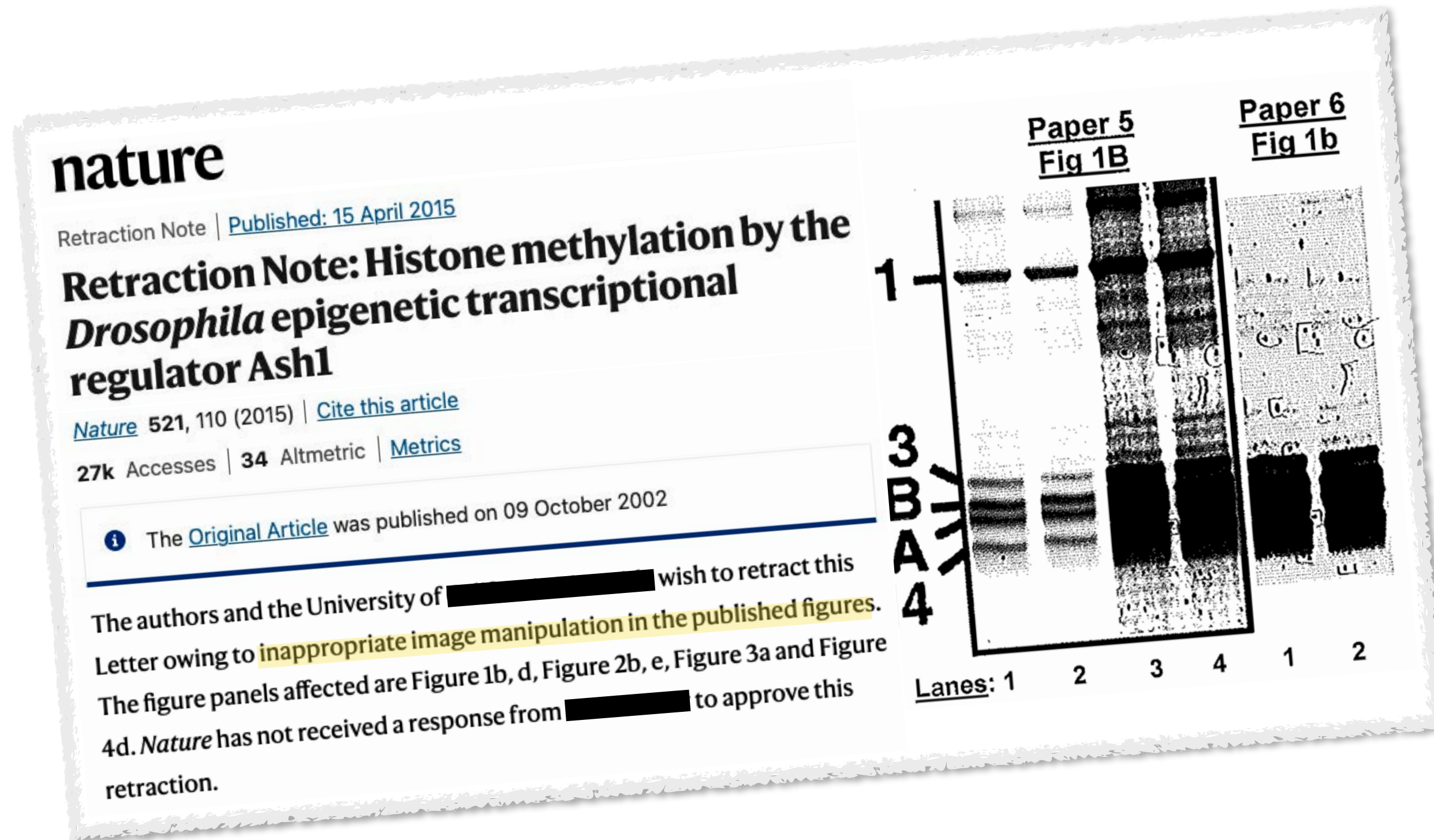
Scientific Integrity

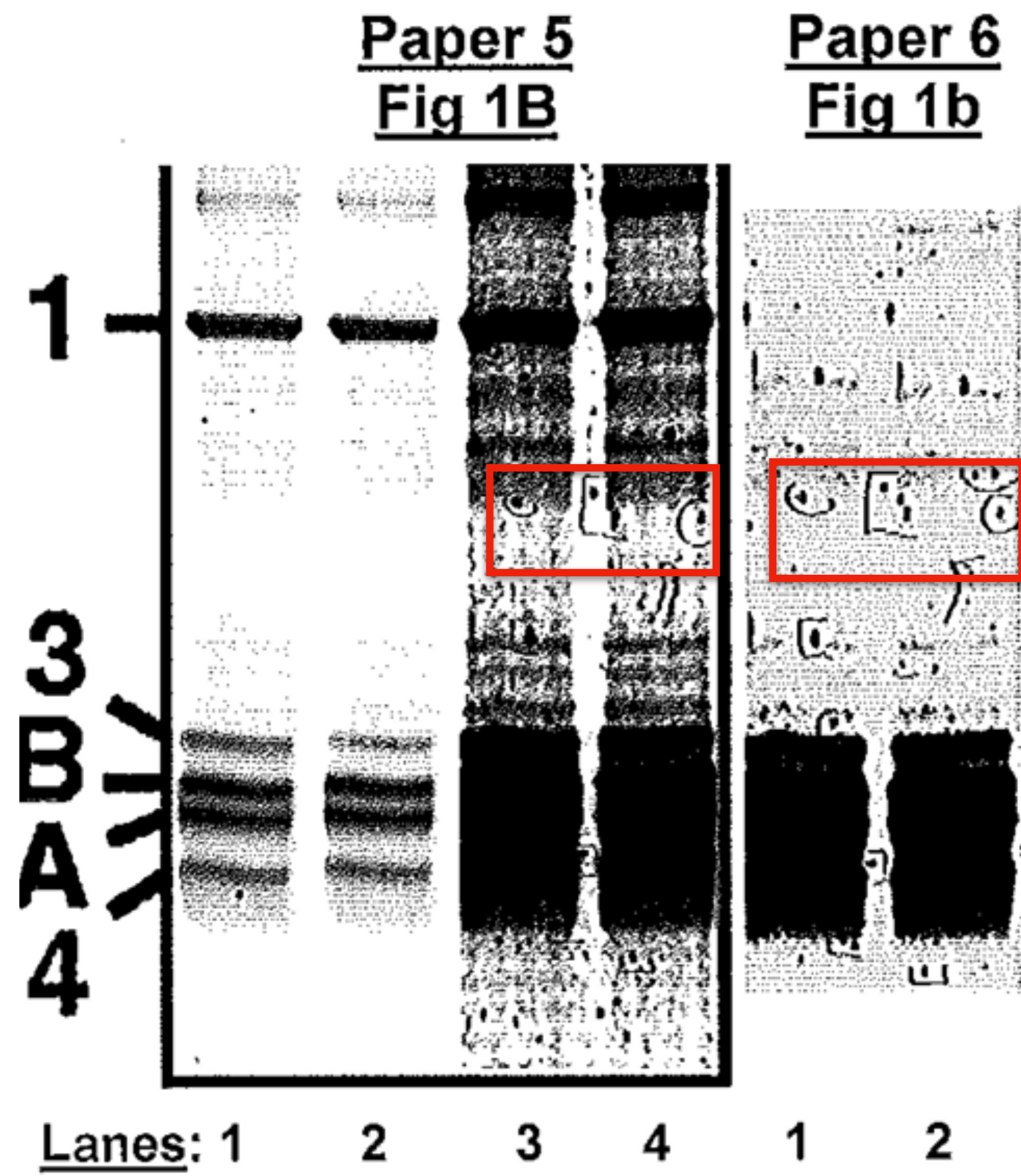
<https://danielmoreira.github.io/project/sciint/>



Jesse Springer
(@SpringerToons)

The Problem





CORRECTIONS & AMENDMENTS

RETRACTION

doi:10.1038/nature14421

Retraction: Histone methylation by the *Drosophila* epigenetic transcriptional regulator Ash1

Nature **419**, 857–862 (2002); doi:10.1038/nature01126

The authors and the University of [REDACTED] wish to retract this Letter owing to inappropriate image manipulation in the published figures. The figure panels affected are Figure 1b, d, Figure 2b, e, Figure 3a and Figure 4d. *Nature* has not received a response from [REDACTED] to approve this retraction.

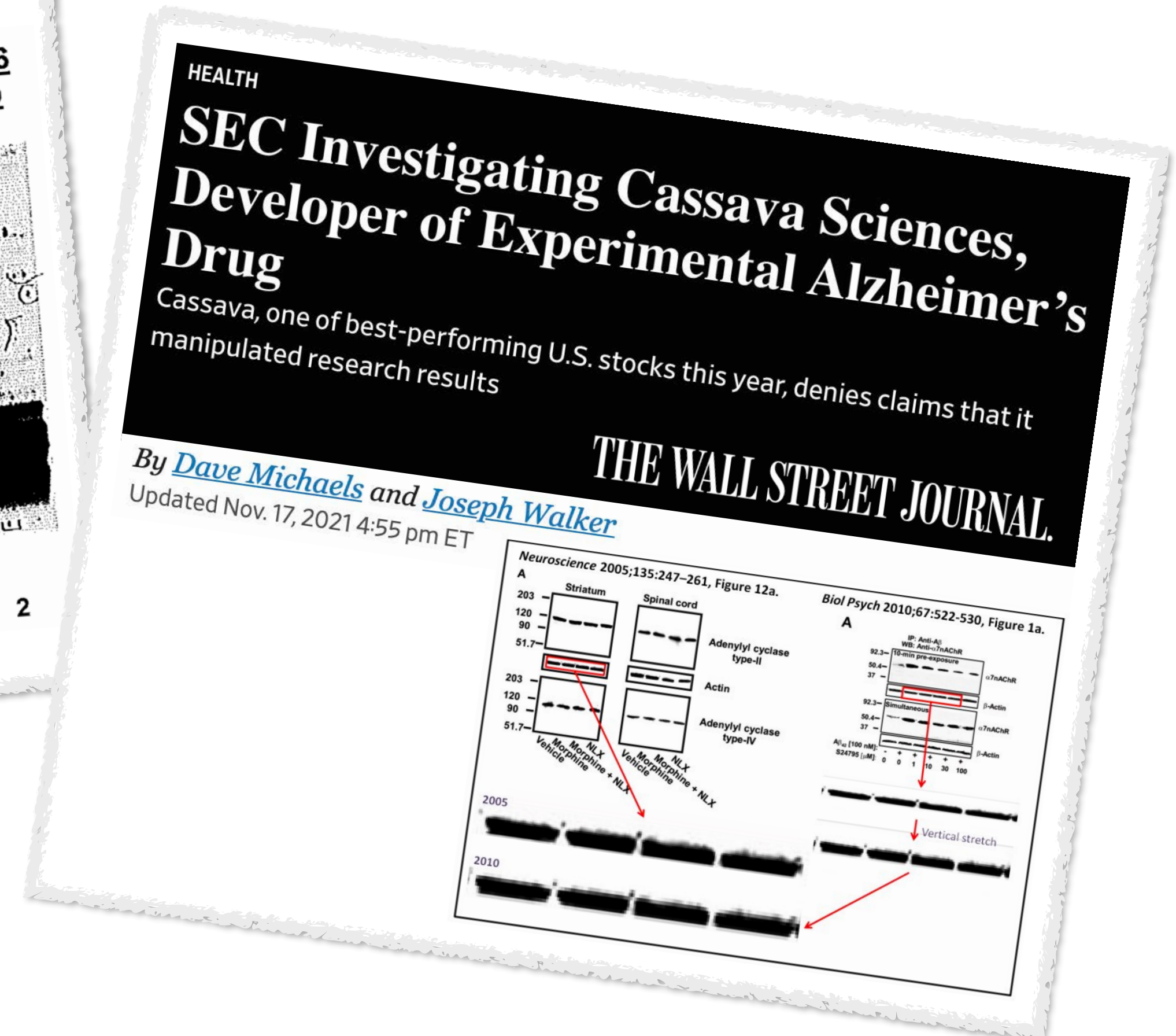
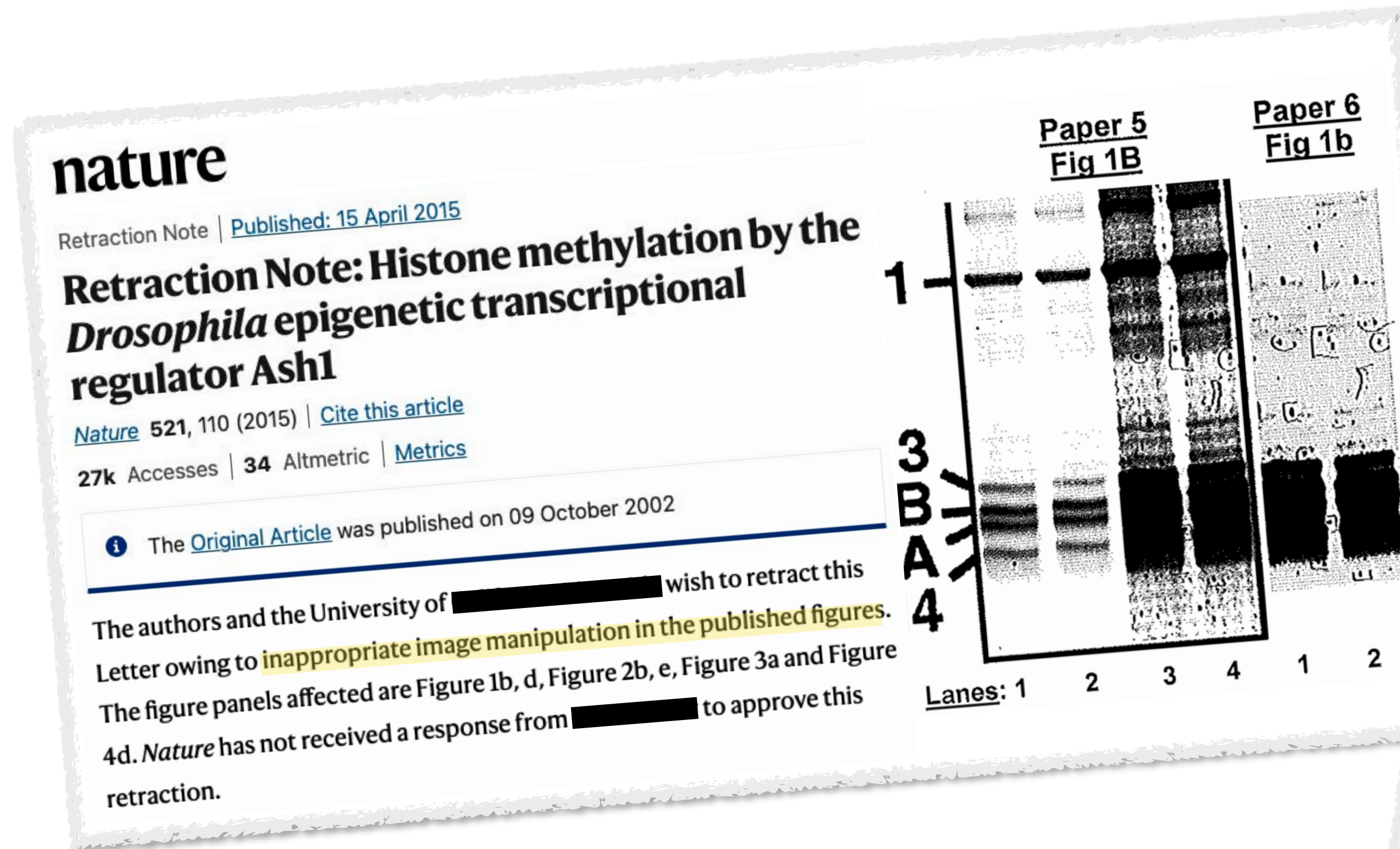
Additional information

The online version of the original article can be found at [10.1038/nature01126](https://doi.org/10.1038/nature01126)

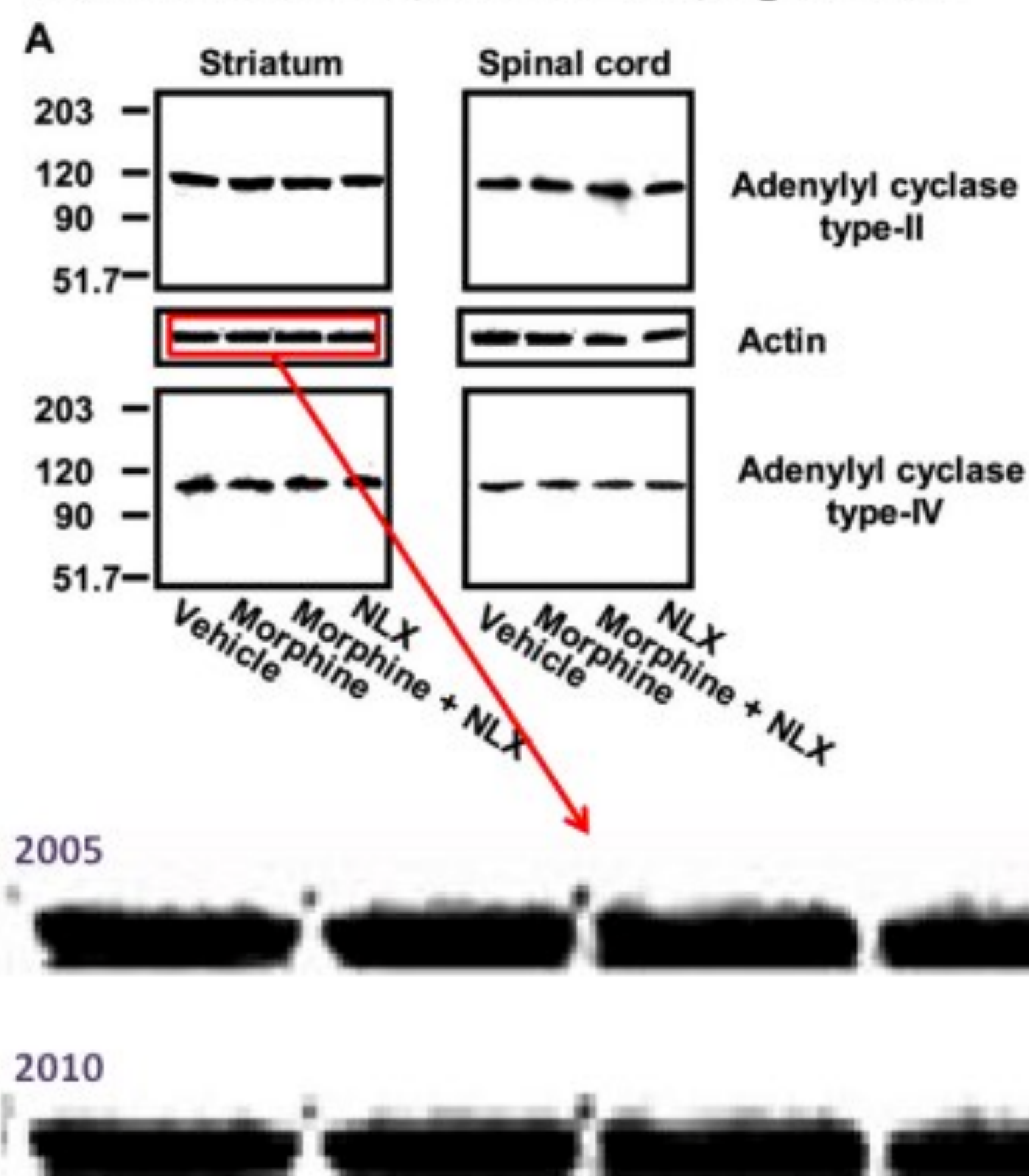


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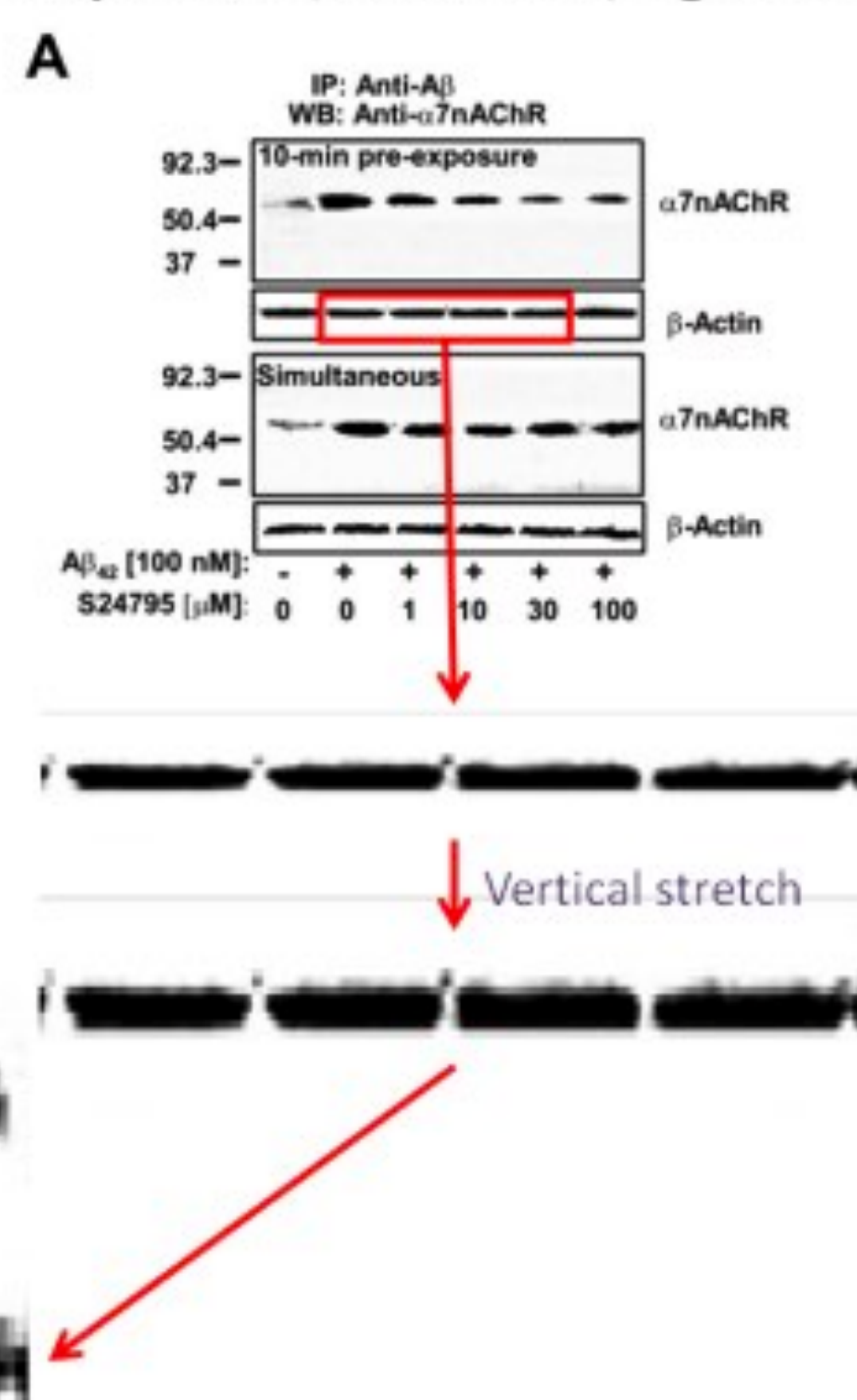
The Problem



Neuroscience 2005;135:247-261, Figure 12a.



Biol Psych 2010;67:522-530, Figure 1a.



HEALTH

SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug

Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results

THE WALL STREET JOURNAL.

By [Dave Michaels](#) and [Joseph Walker](#)

Updated Nov. 17, 2021 4:55 pm ET

The Problem

nature

Retraction Note | Published: 15 April 2015

Retraction Note: Histone methylation by the *Drosophila* epigenetic transcriptional regulator Ash1

[Nature](#) 521, 110 (2015) | [Cite this article](#)

27k Accesses | 34 Altmetric | [Metrics](#)

The [Original Article](#) was published on 09 October 2002

The authors and the University of [redacted] wish to retract this Letter owing to **inappropriate image manipulation in the published figures**. The figure panels affected are Figure 1b, d, Figure 2b, e, Figure 3a and Figure 4d. *Nature* has not received a response from [redacted] to approve this retraction.

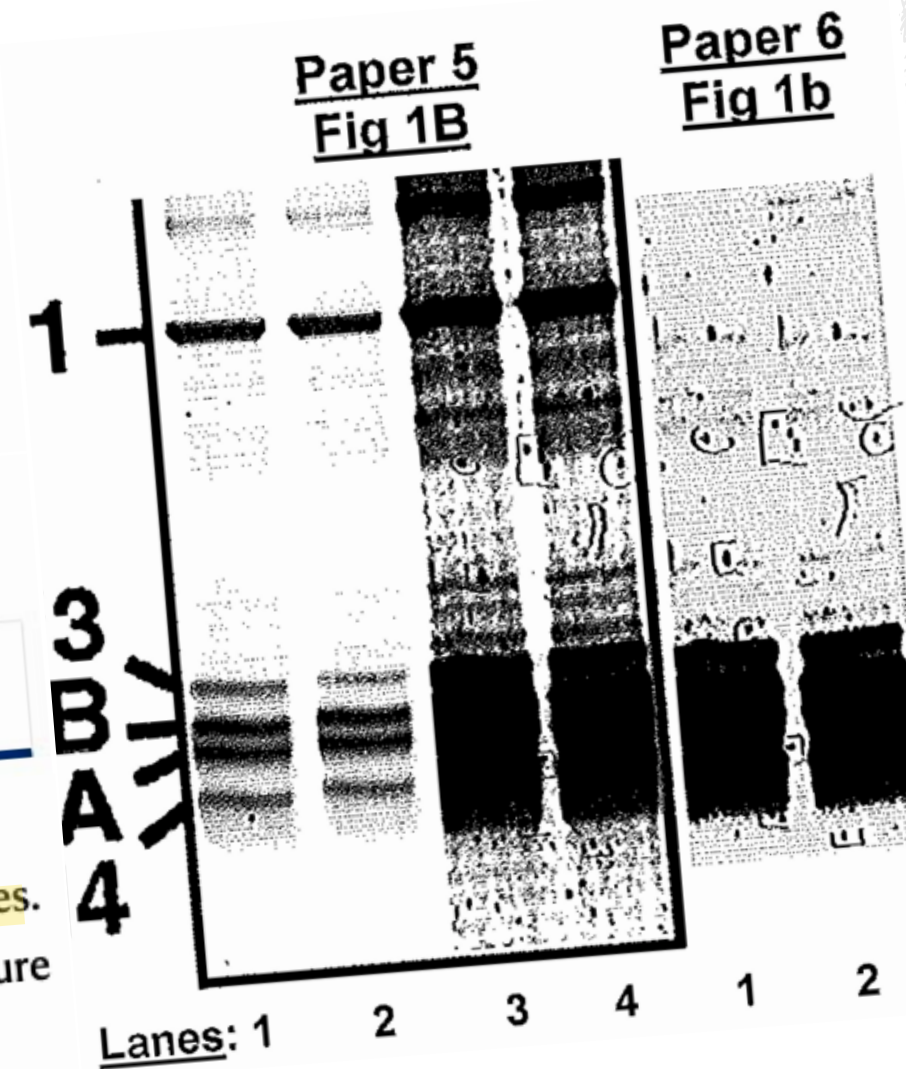


Elisabeth Bik
@MicrobiomDigest

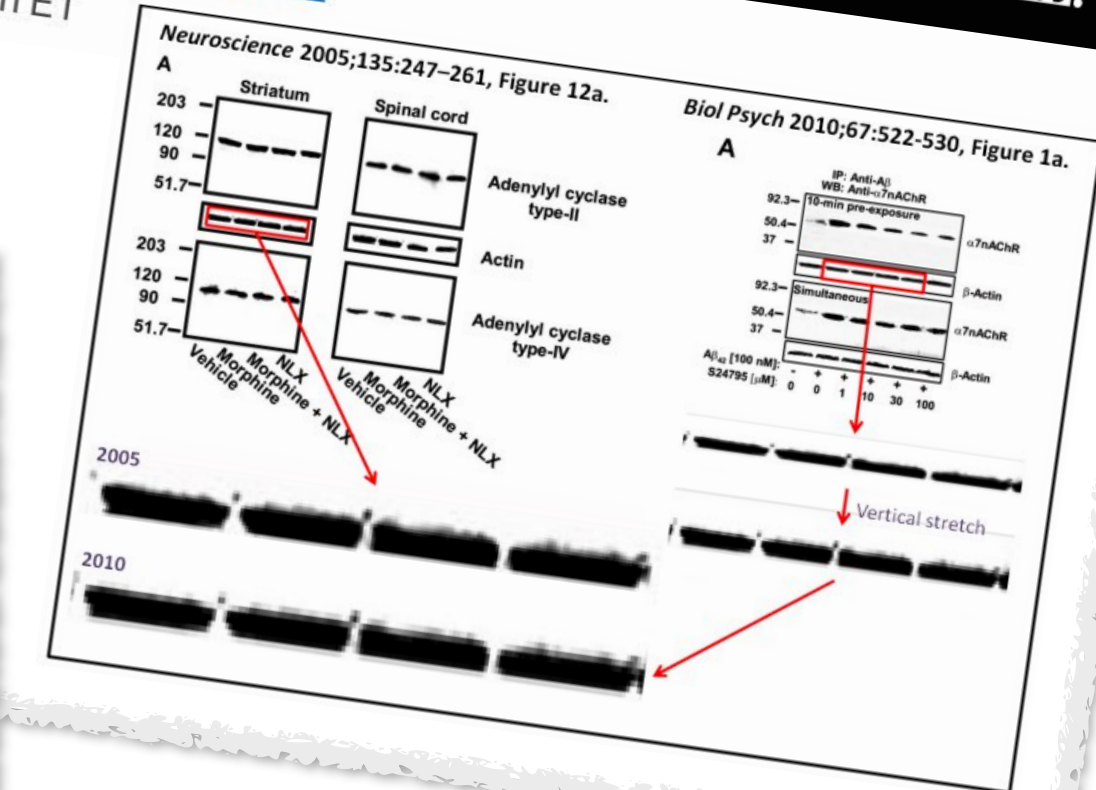
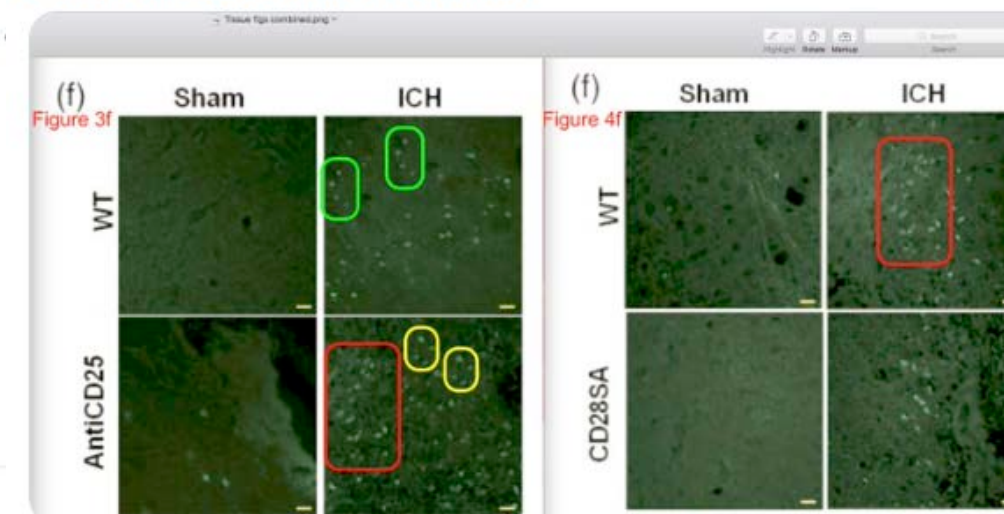
Retraction of a paper by authors of The Third Military Medical University, Zhengzhou University, and @JohnsHopkins, 5 months after posting this to @PubPeer. pubpeer.com/publications/4...

3:17 PM · Oct 2, 2022 · Twitter Web App

3 Retweets 41 Likes



HEALTH
SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug
Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results
THE WALL STREET JOURNAL.
By [Dave Michaels](#) and [Joseph Walker](#)
Updated Nov. 17, 2021 4:55 pm ET

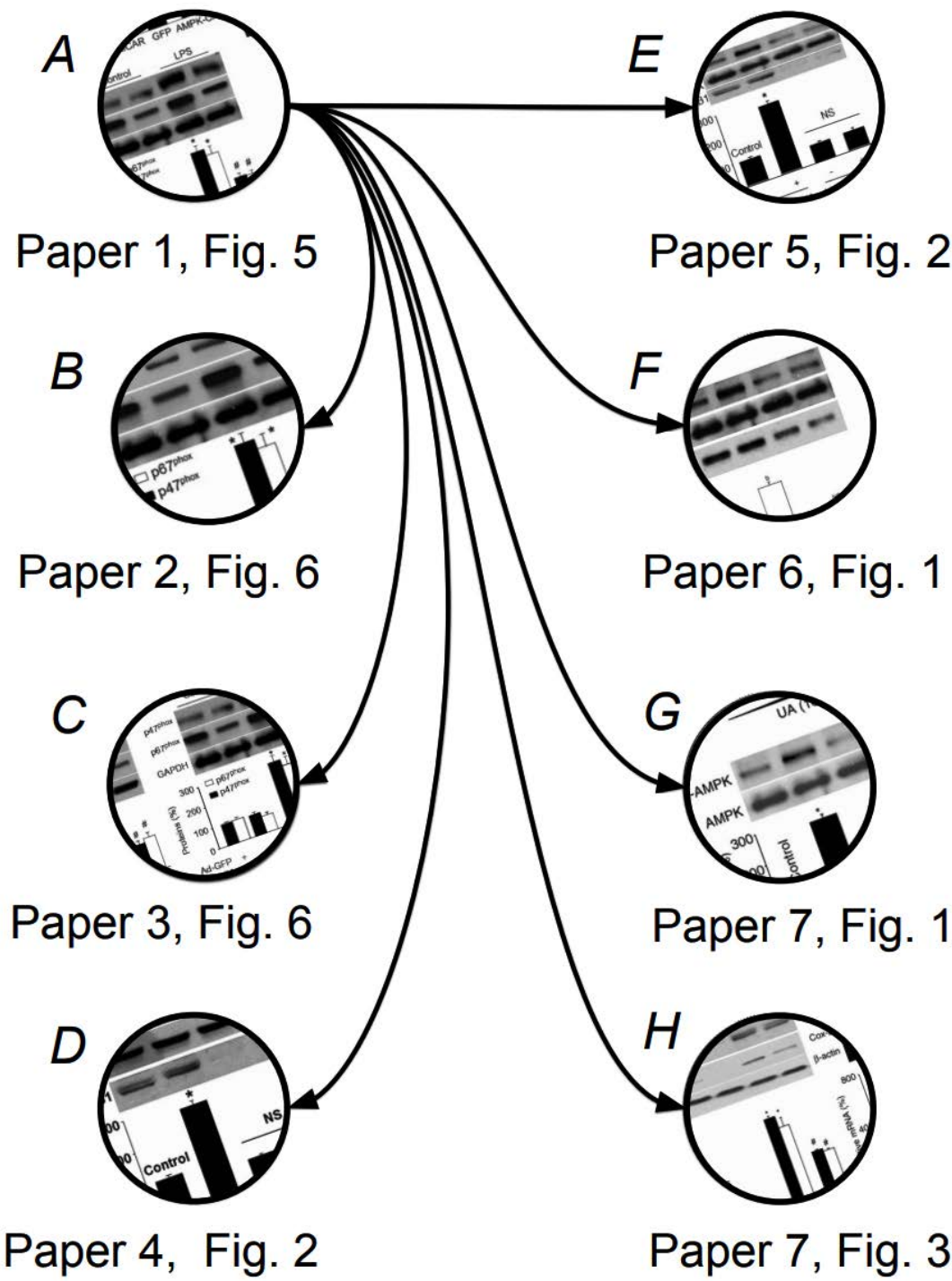


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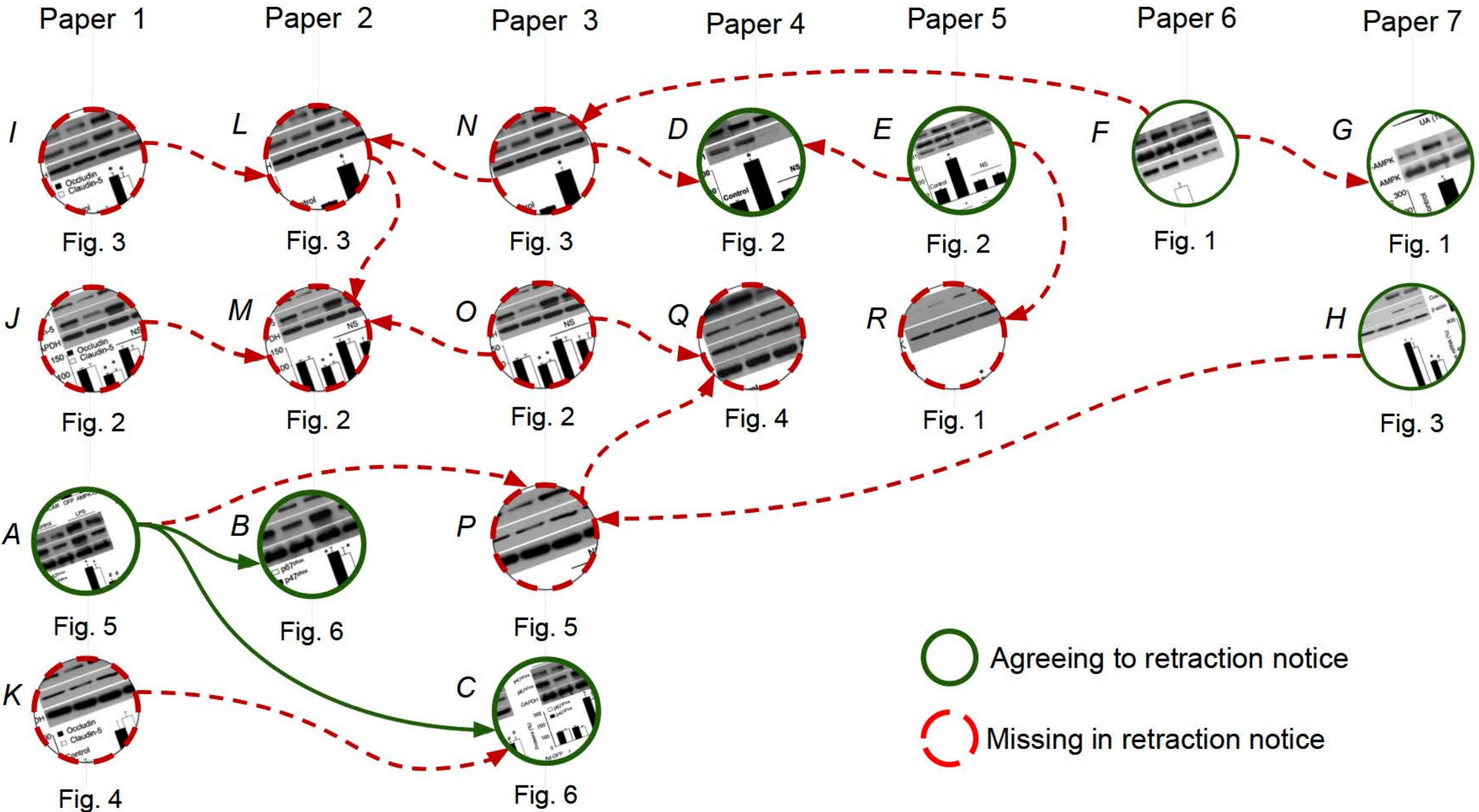
Provenance Analysis

Ground truth

(according to retraction notice)



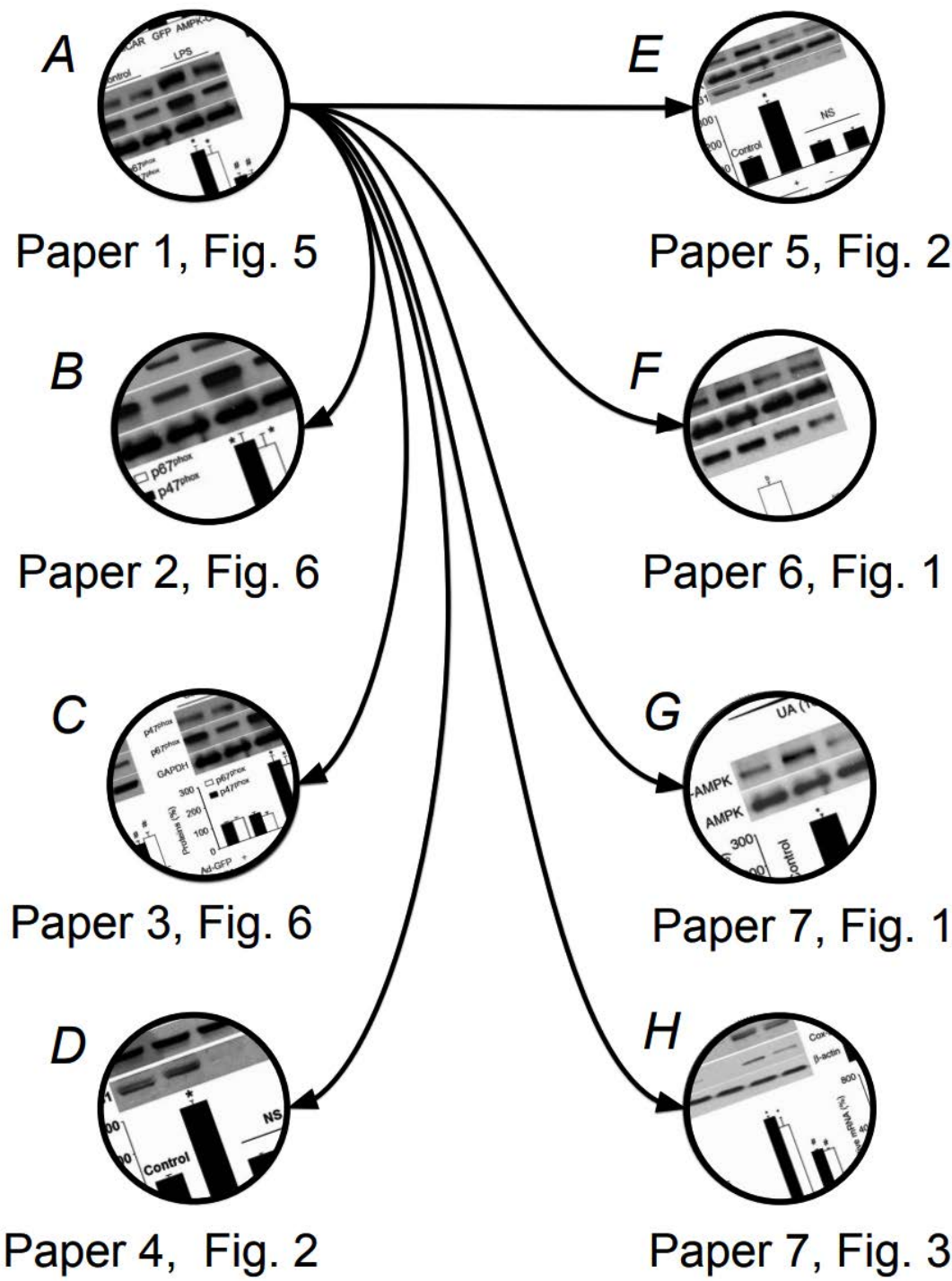
Our findings



Provenance Analysis

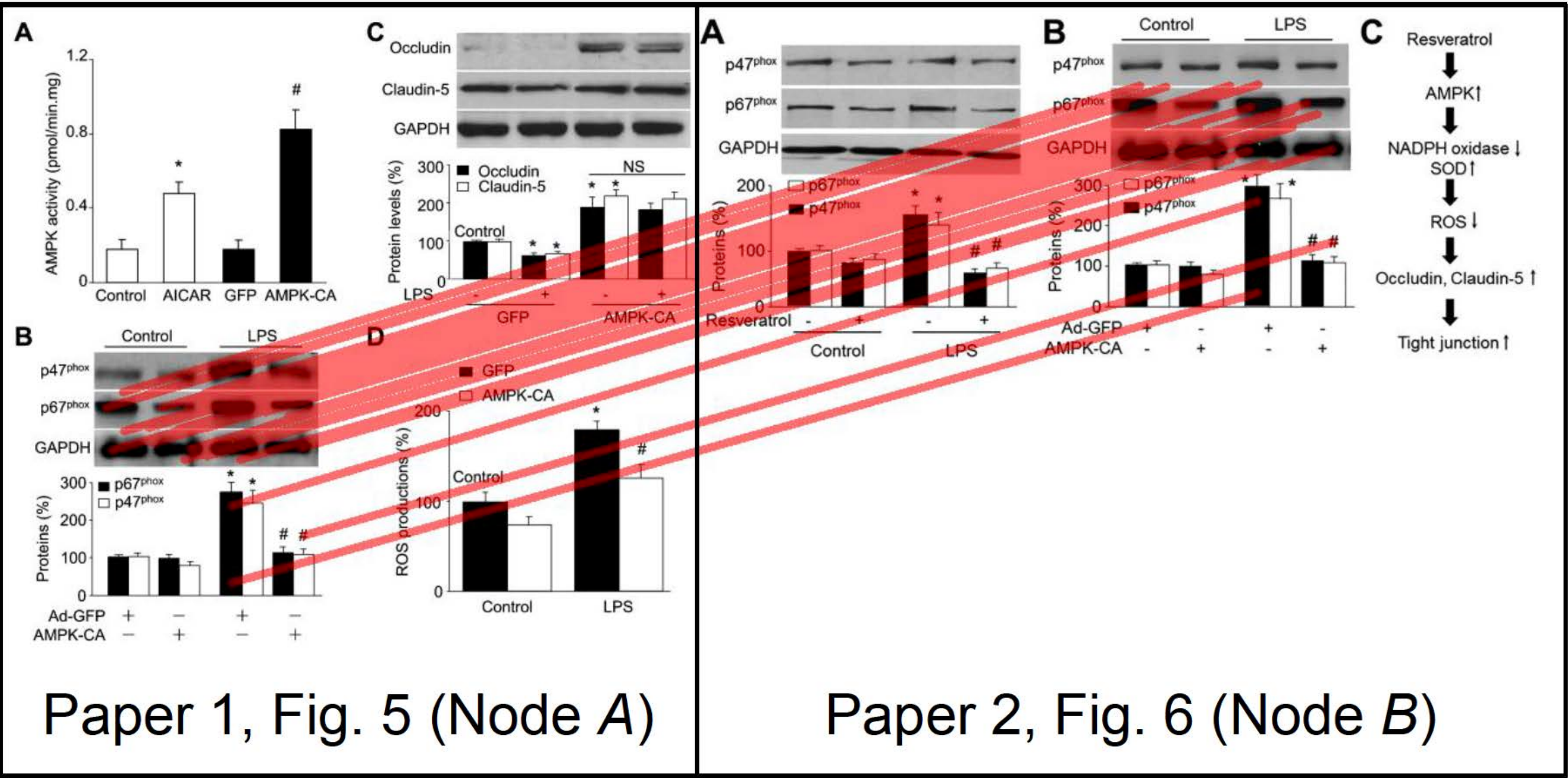
Ground truth

(according to retraction notice)



Our findings

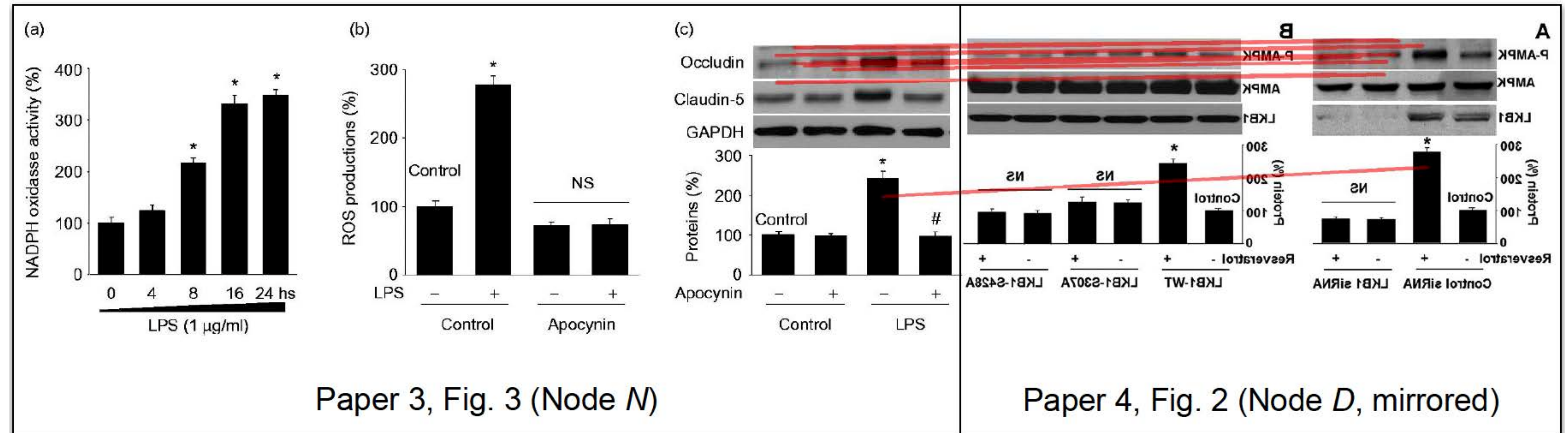
(in accordance with retraction notice)



Provenance Analysis

Our findings

(not reported in the retraction notice)



10.1371/journal.pone.0190562

Paper Mills

<https://tinyurl.com/4ukfbka7>

Science

PAPER TRAIL

In the latest twist of the publishing arms race, firms churning out papers are taking to bribing journal editors

18 JAN 2024 • 2:00 PM ET • P

These are organized crime rings that are committing large-scale fraud.

AT LEAST TENS OF MILLIONS flow to the paper mill industry



Elisabeth Bik @MicrobiomDigest · Jun 19, 2023

Wow, this is pretty blatant.

Author has gotten acceptance letter for their paper from the journal "Molecular Biology and Evolution", and now authorship positions are being sold on @facebook for 5K or more.

#PaperMill

<https://tinyurl.com/3xtmedrb>



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Paper Mills

Retraction Watch

**Want to earn \$10k per month?
Join the “journals mafia”**

**The authors pay to publish the articles,
the company shares the profits with journals
that publish the paper.**

<https://tinyurl.com/4m3t9umb>

Paper Mills



Are you an editor of
the journal or a
member of editorial
board?

It is necessary to publish articles.
The same work that you do, but you can get more
money doing this with us.
The profit is from 1,000 up to 10,000 dollars per a month.



10.000 \$ PER
MONTH

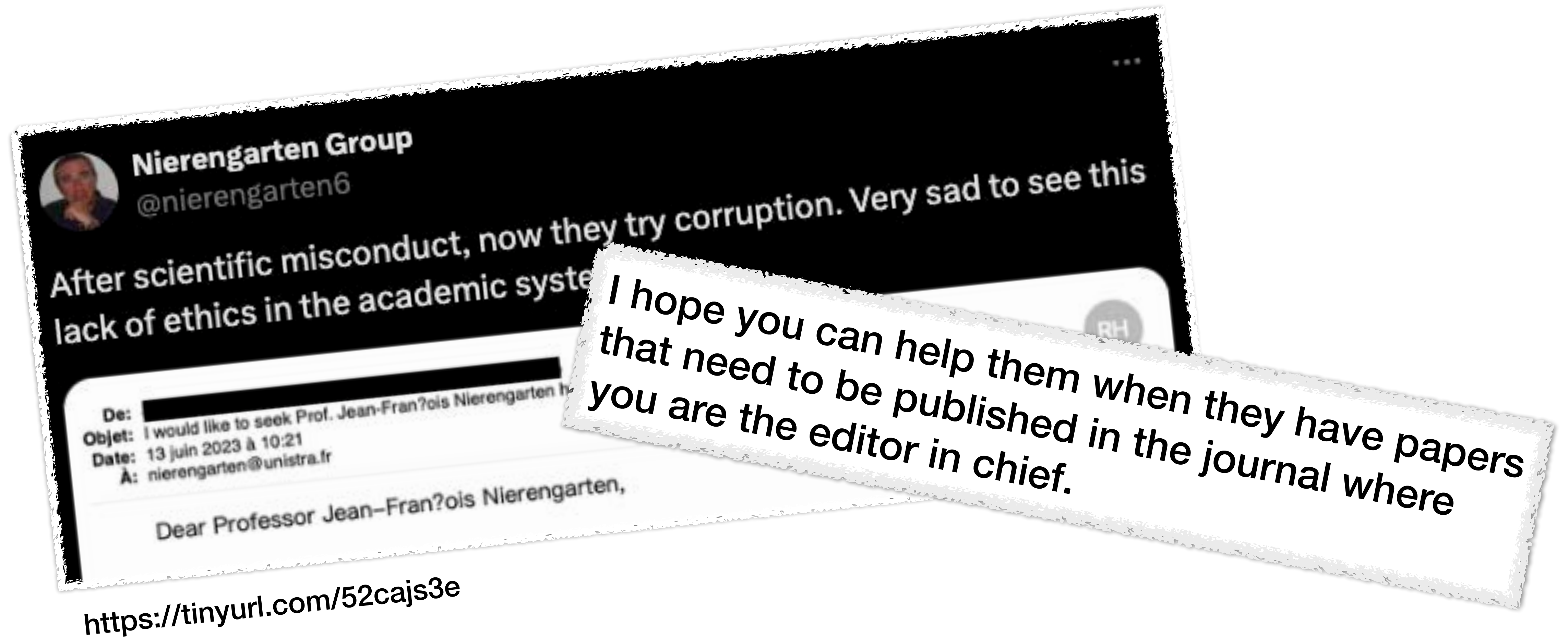


PUBLISHING
BUSINESS

A close-up shot of a man with grey hair, wearing a dark tuxedo jacket, a white shirt, and a black bow tie. He has a serious, almost somber expression and is looking down and slightly to his left. A red pocket square is visible in his jacket. In the foreground, the back of a person's head with dark hair is visible, partially obscuring the man's face. The background is dark and out of focus, with another person in a tuxedo visible in the distance.

I'm gonna make them an offer they can't refuse.

Paper Mills



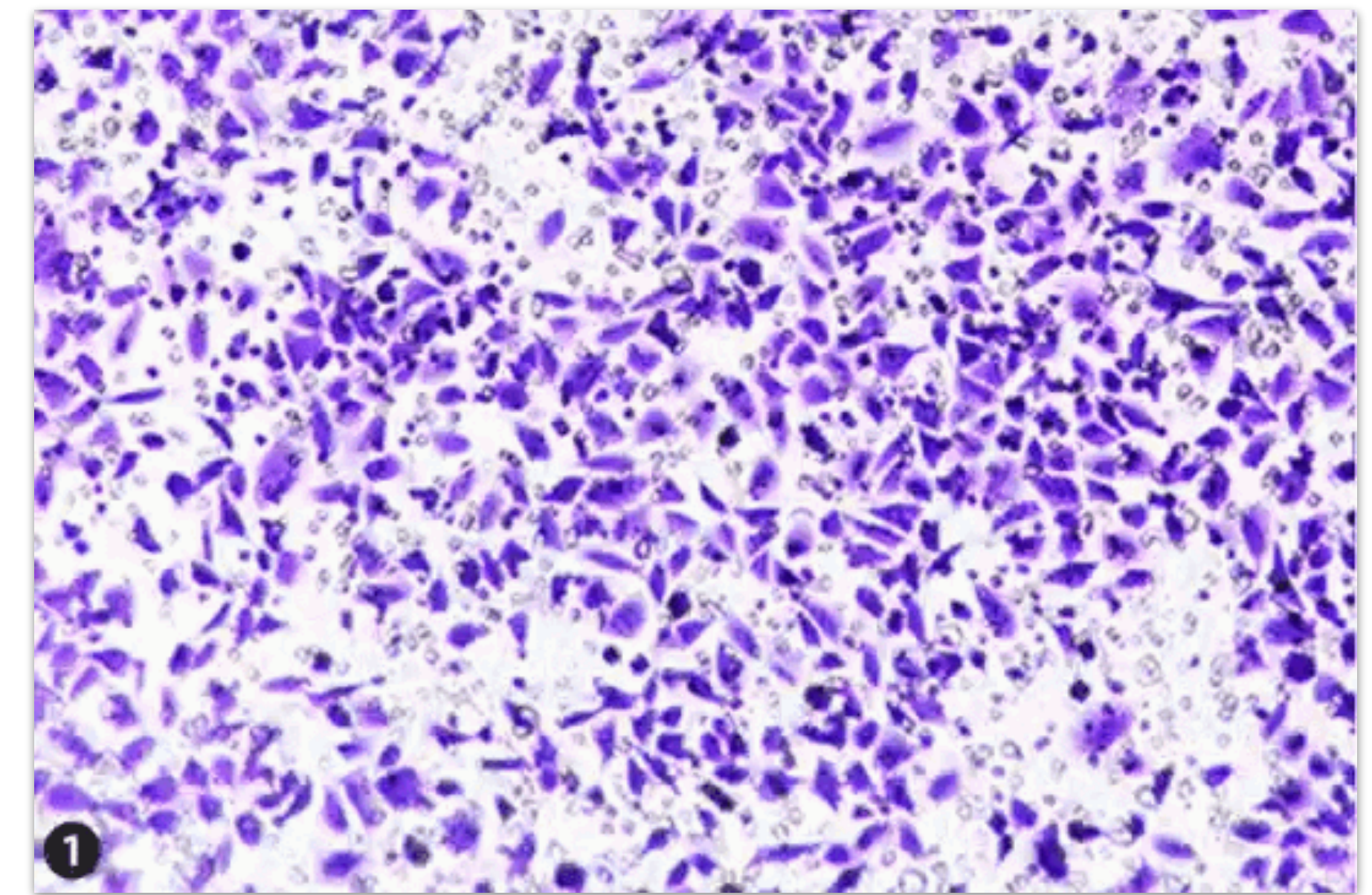
<https://tinyurl.com/52cajs3e>

Paper Mills

Problems with Images?



<https://tinyurl.com/2p8ecptc>



<https://tinyurl.com/4znhmpa6>



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Paper Mills

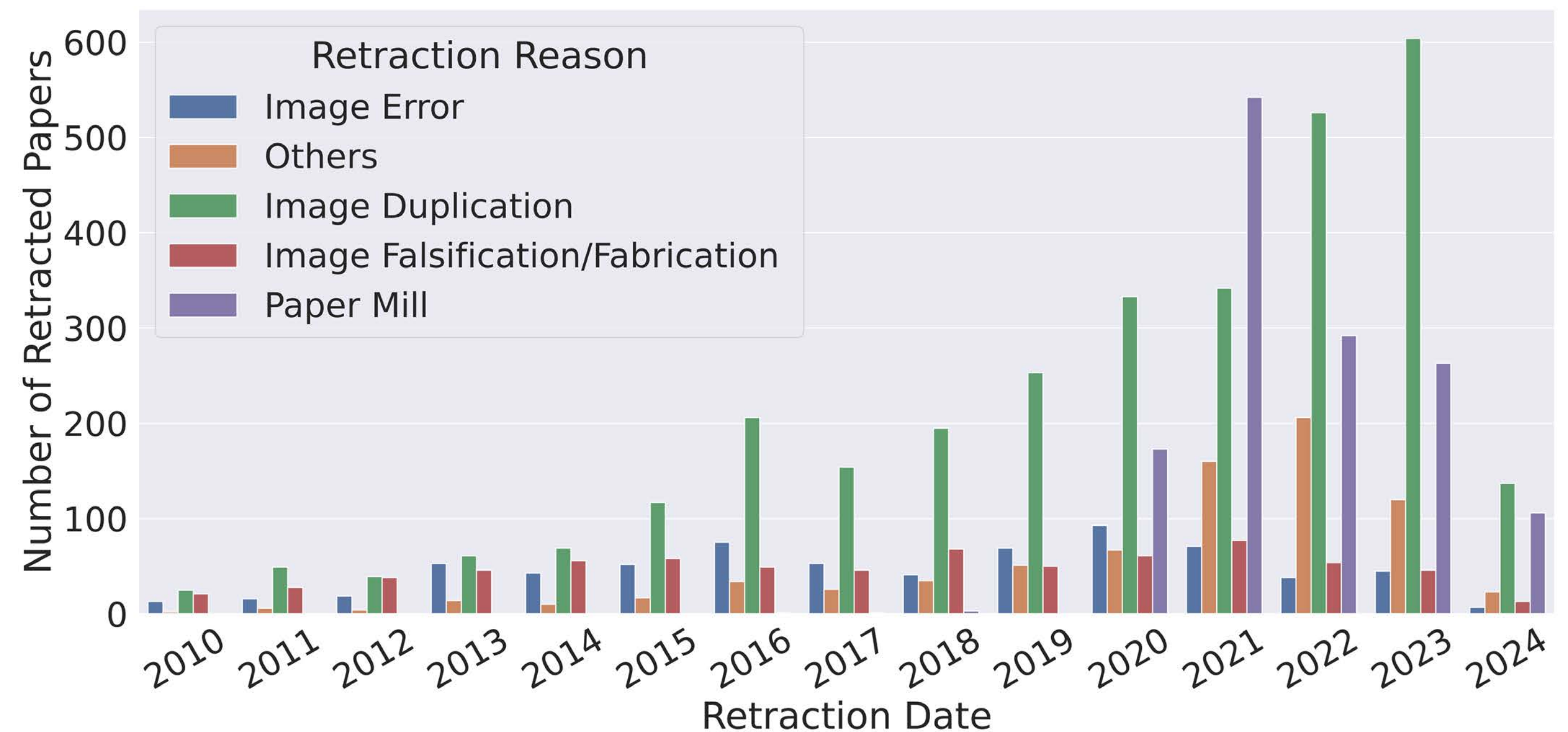
Problems with Images?

PLOS ONE

Unveiling scientific articles from paper mills with provenance analysis

Cardenuto, Moreira, and Rocha, 2024

<https://tinyurl.com/2fx3p6tj>



Paper Mills

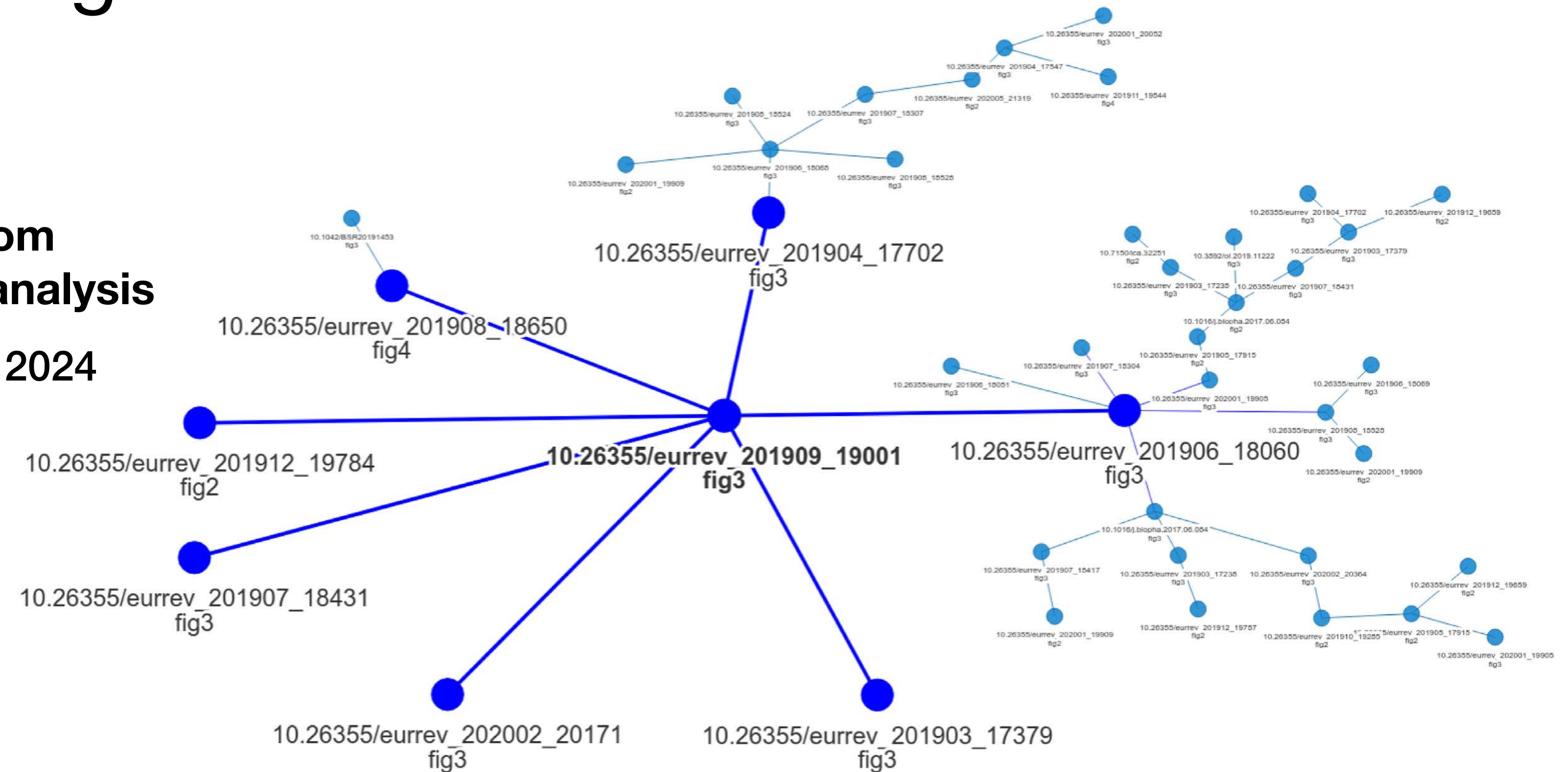
Problems with Images?

PLOS ONE

Unveiling scientific articles from paper mills with provenance analysis

Cardenuto, Moreira, and Rocha, 2024

<https://tinyurl.com/2fx3p6tj>





We can use AI...

AI-generated Content



ChatGPT



DALL-E 3



Midjourney



Hugging Face

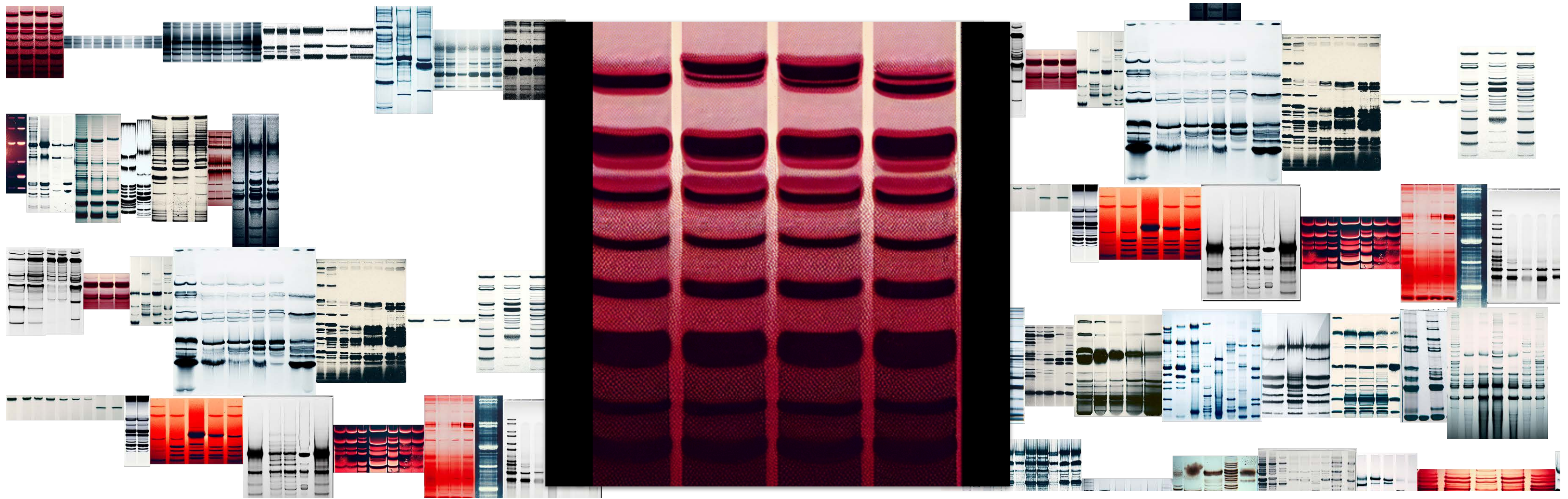
DALL-E 3



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AI-generated Content

AI-generated Western blots!



DALLE-3

AI-generated Content

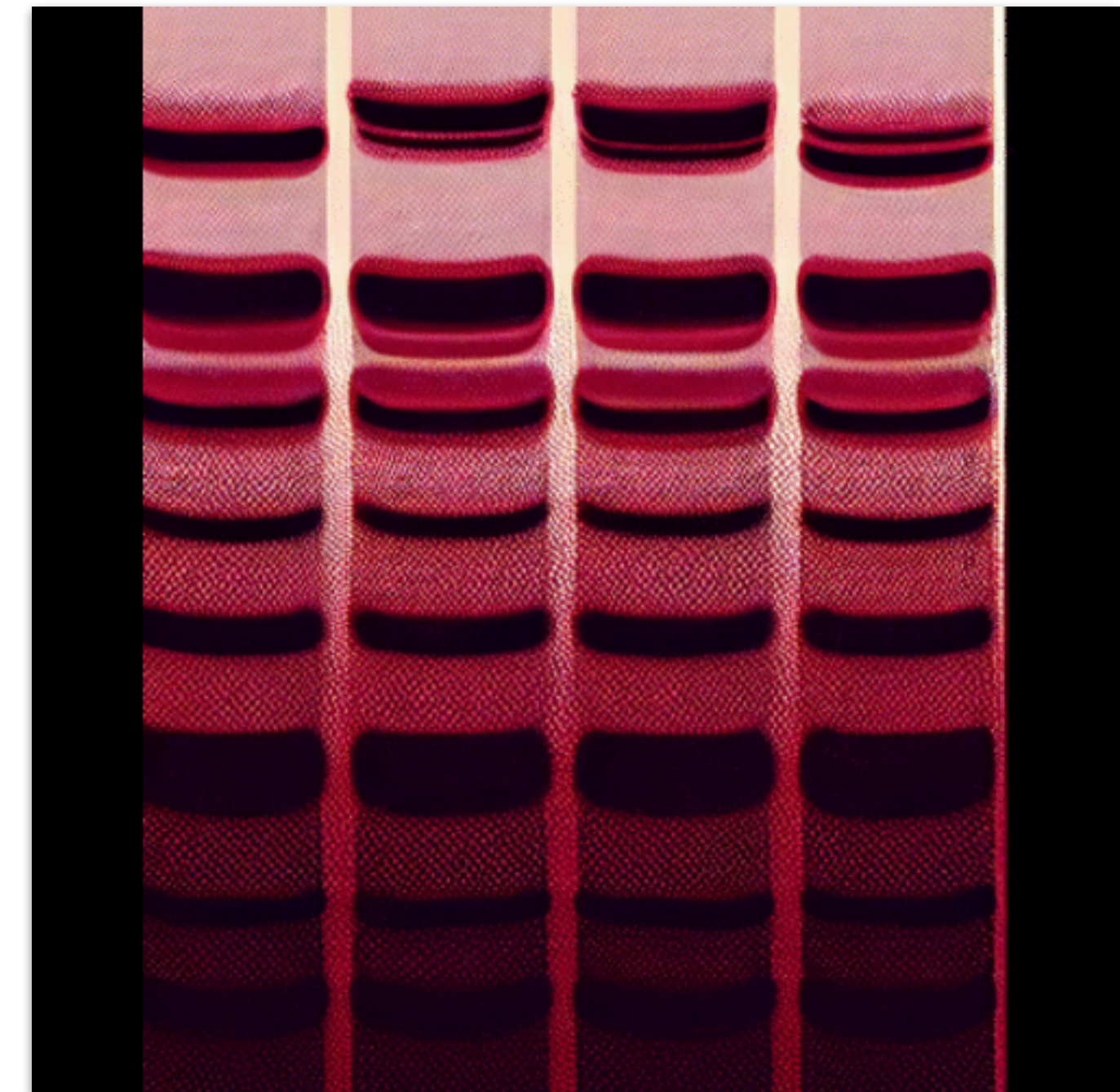
AI-generated Western blots!



Stable Diffusion

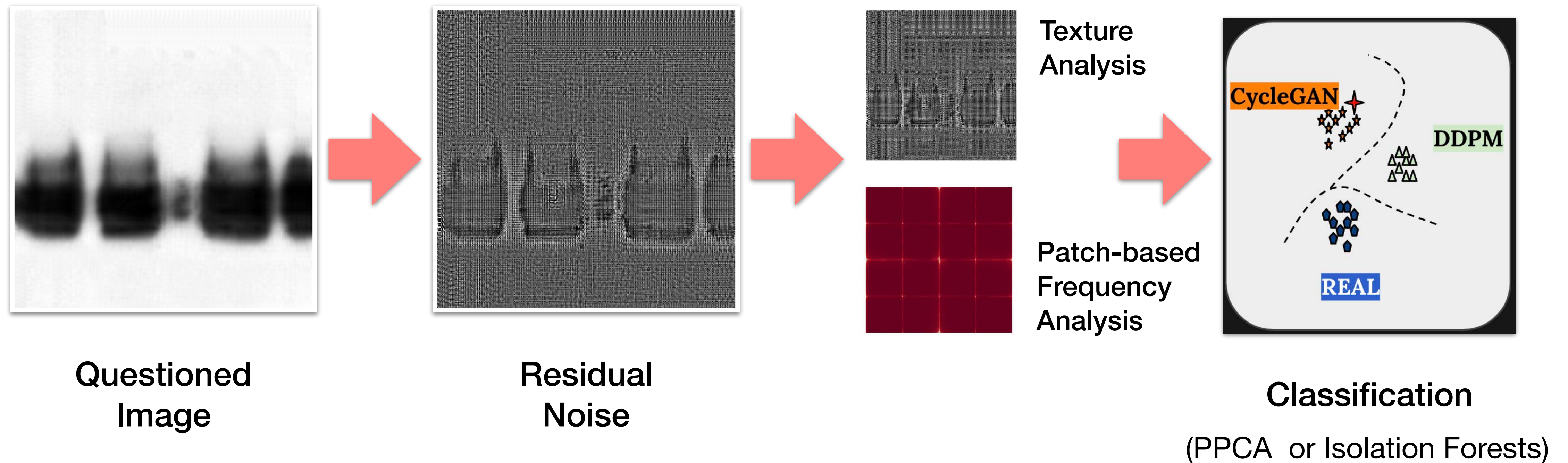
AI-generated Content

What can we do about it?



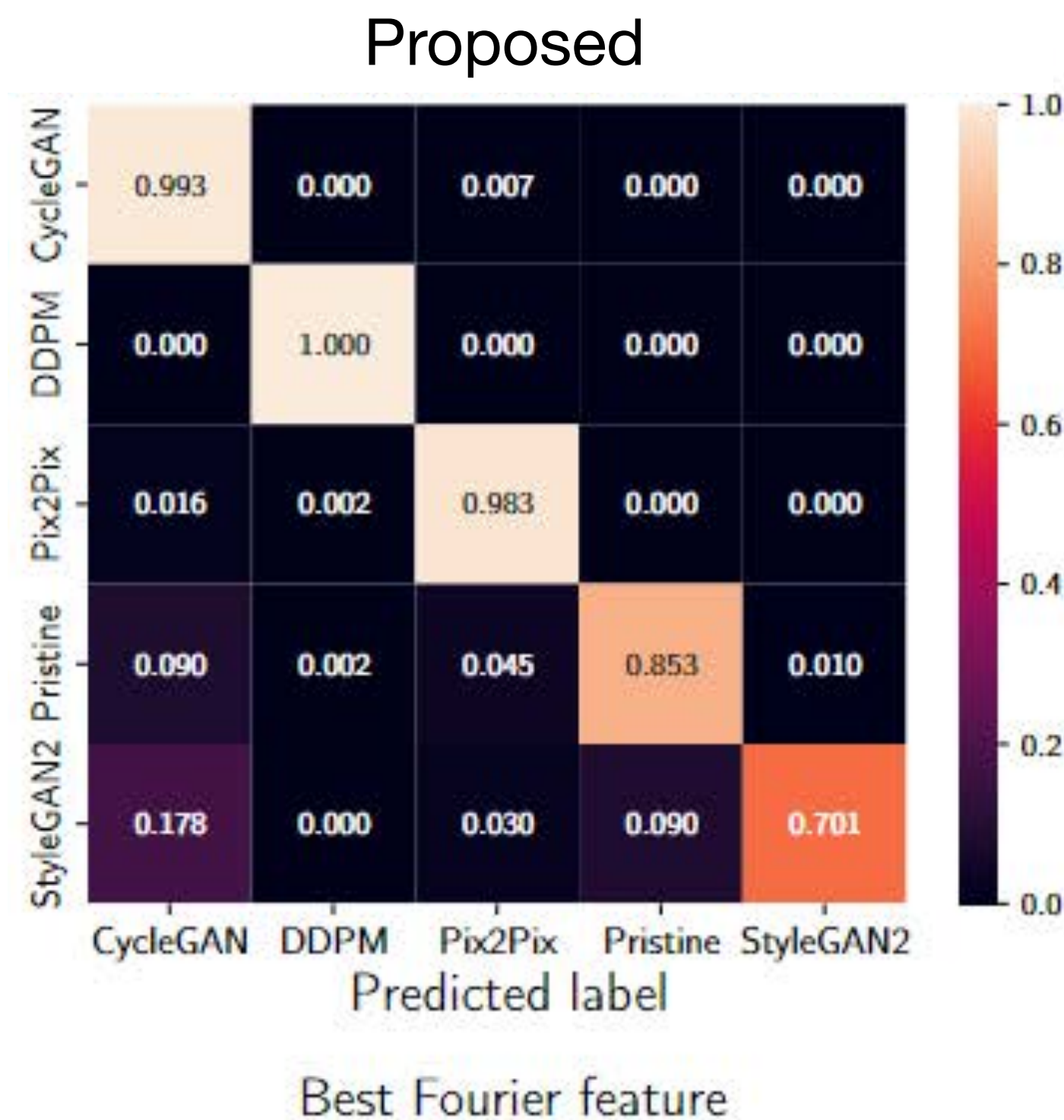
Synthetic Image Attribution

Detection and Source Attribution



Synthetic Image Attribution

Detection and Source Attribution



Explainable Artifacts for Synthetic Western Blot Source Attribution

Cardenuto, Mandelli, Moreira, Bestagini, Delp, and Rocha, 2024

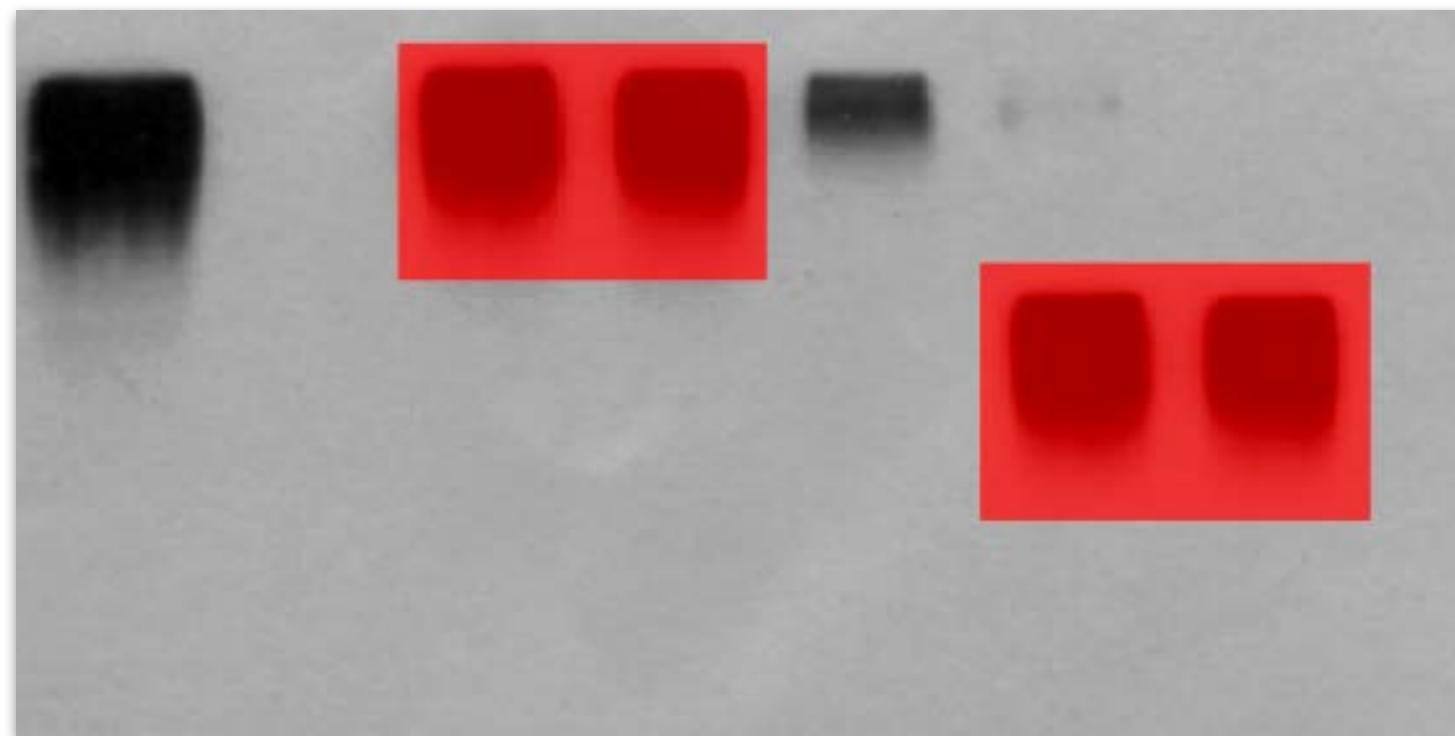
IEEE WIFS 2024
tinyurl.com/4fwa7syb

Kaggle Competition

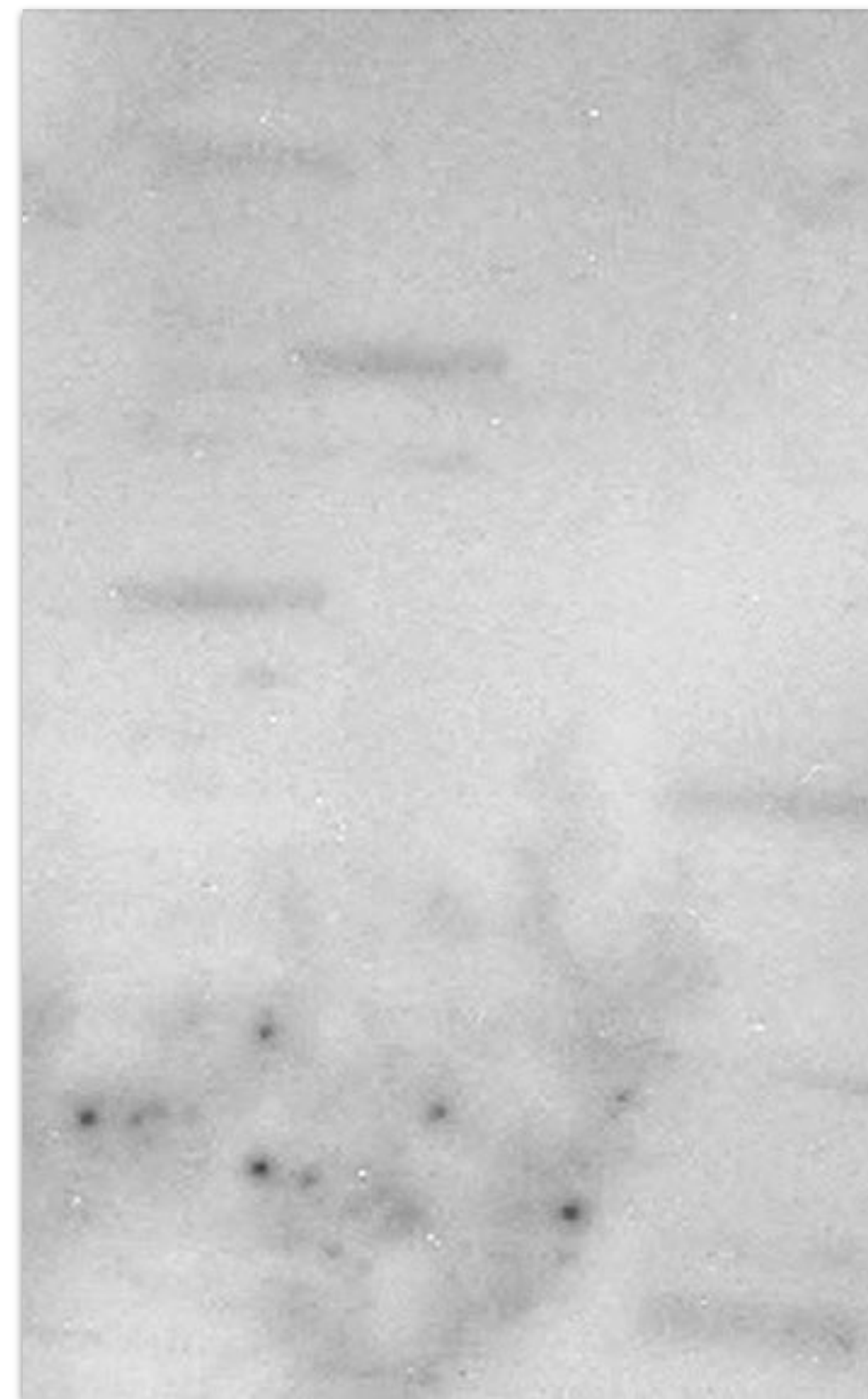
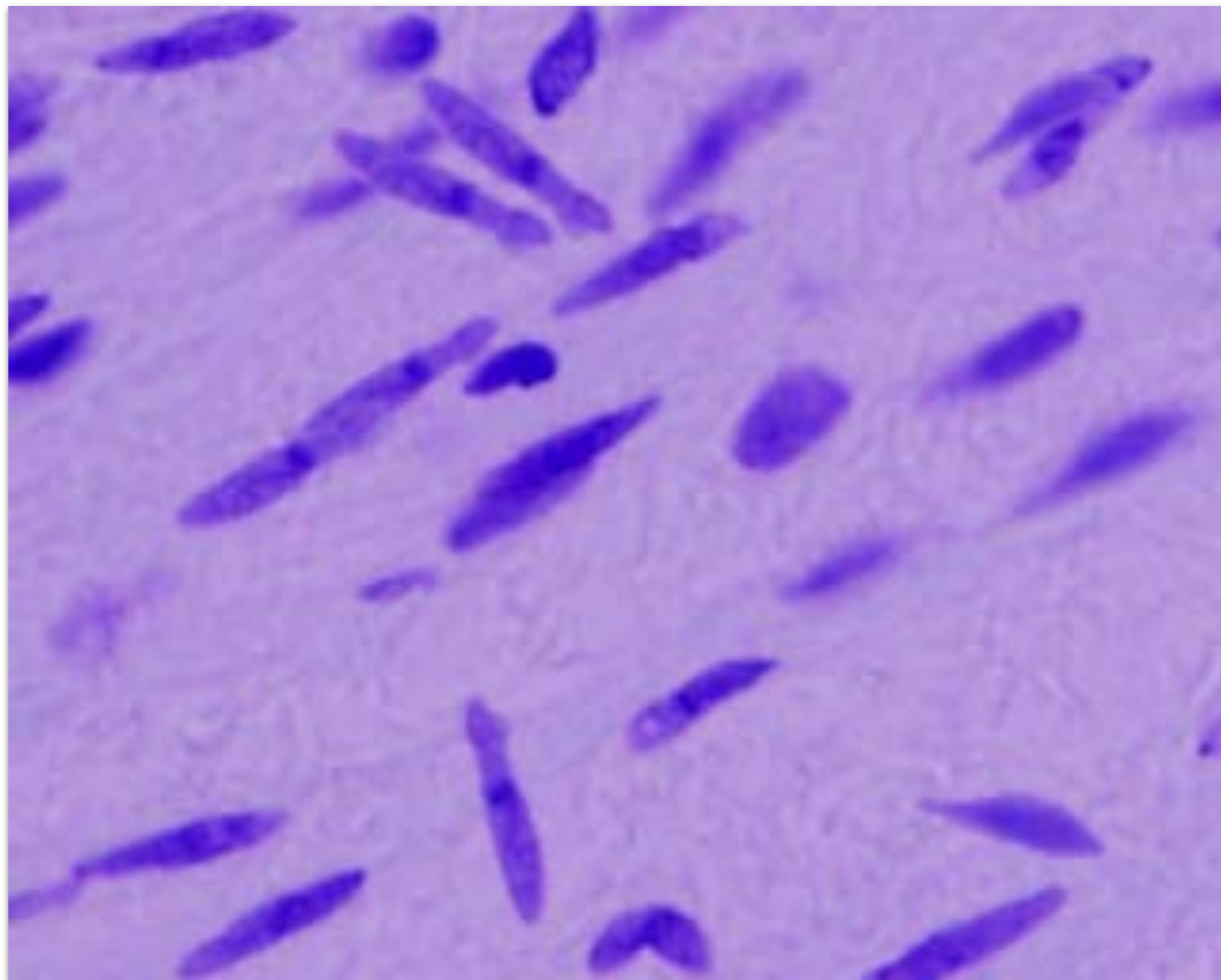
Scientific Image Forgery Detection

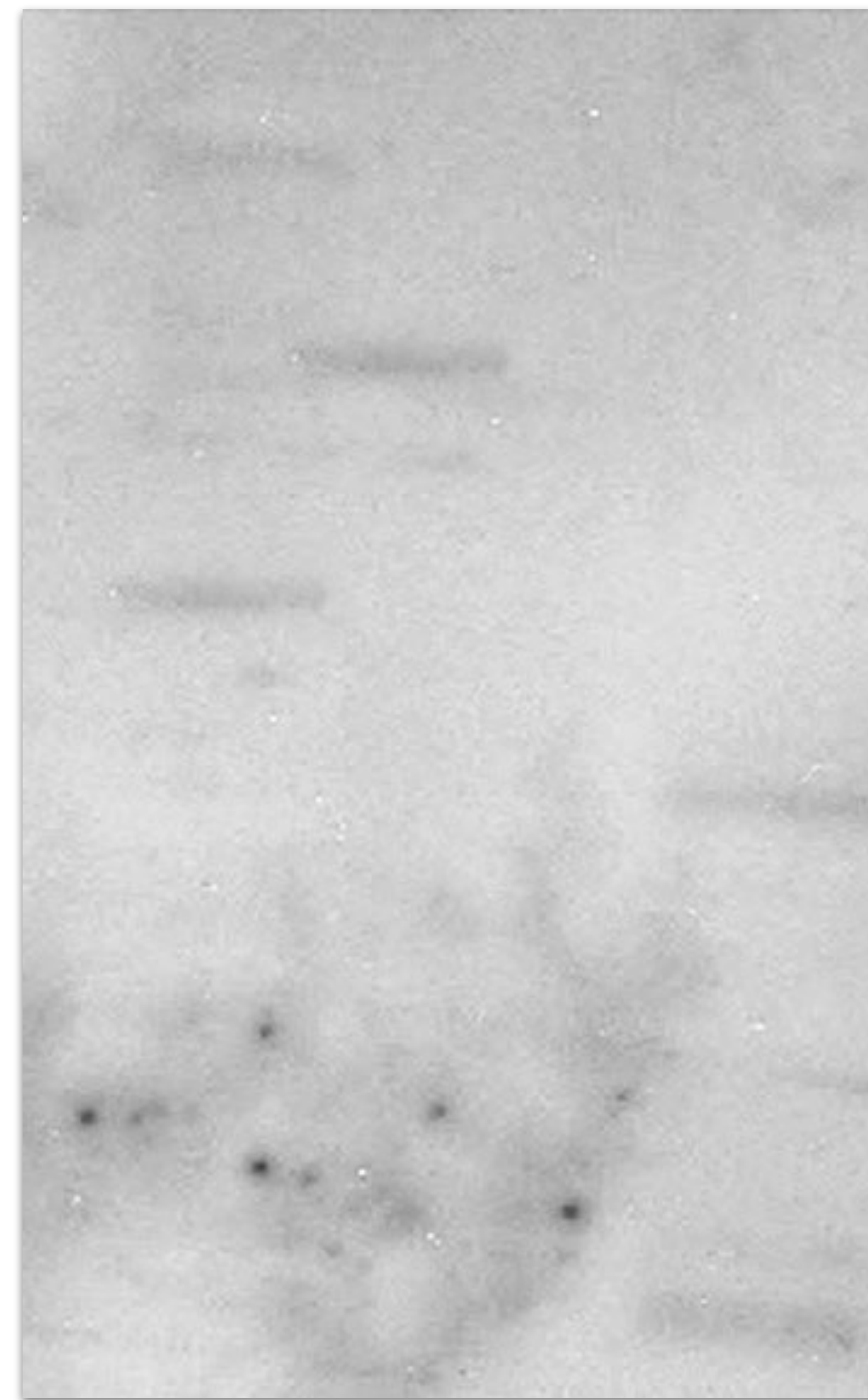
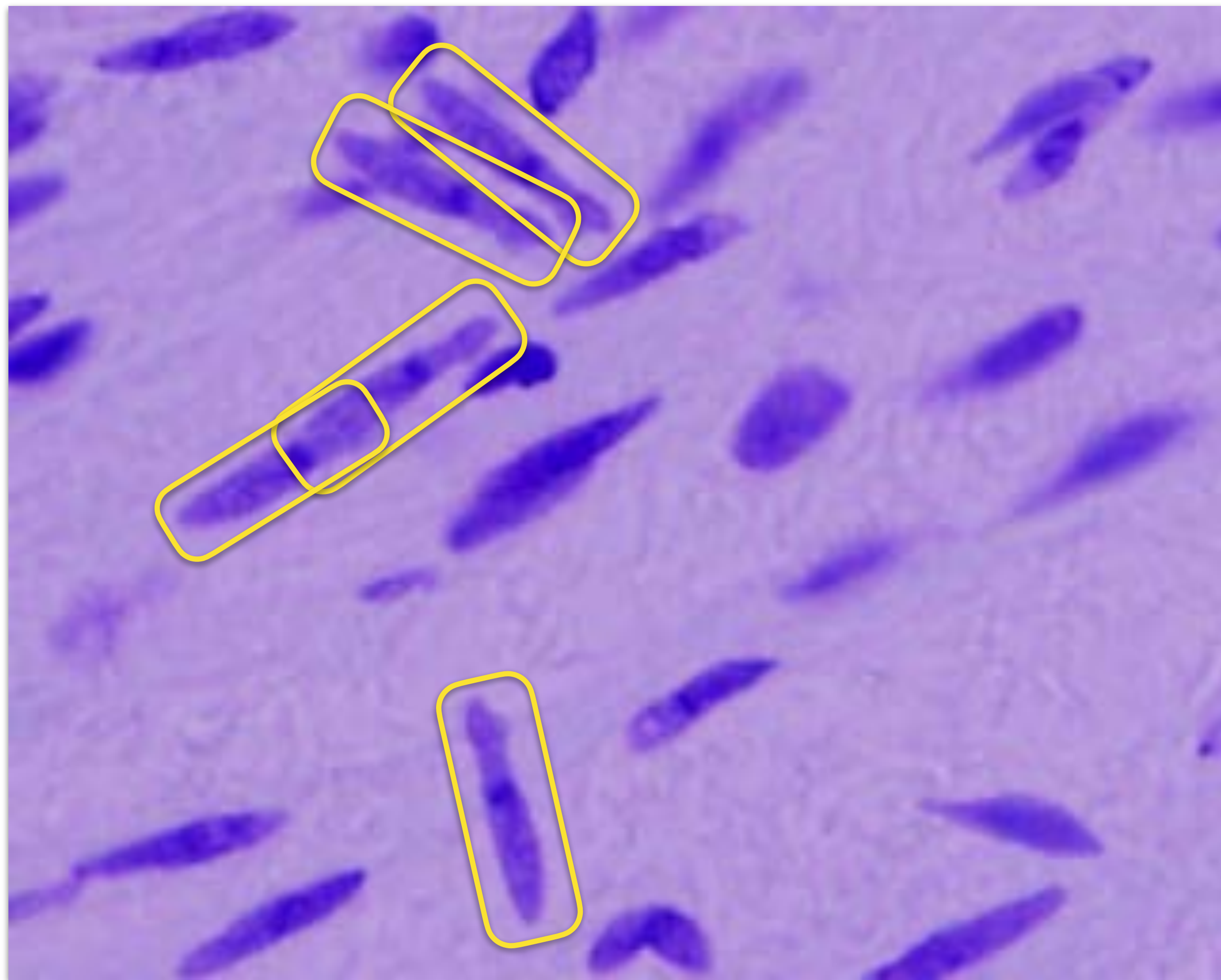
tinyurl.com/4zj9y62x

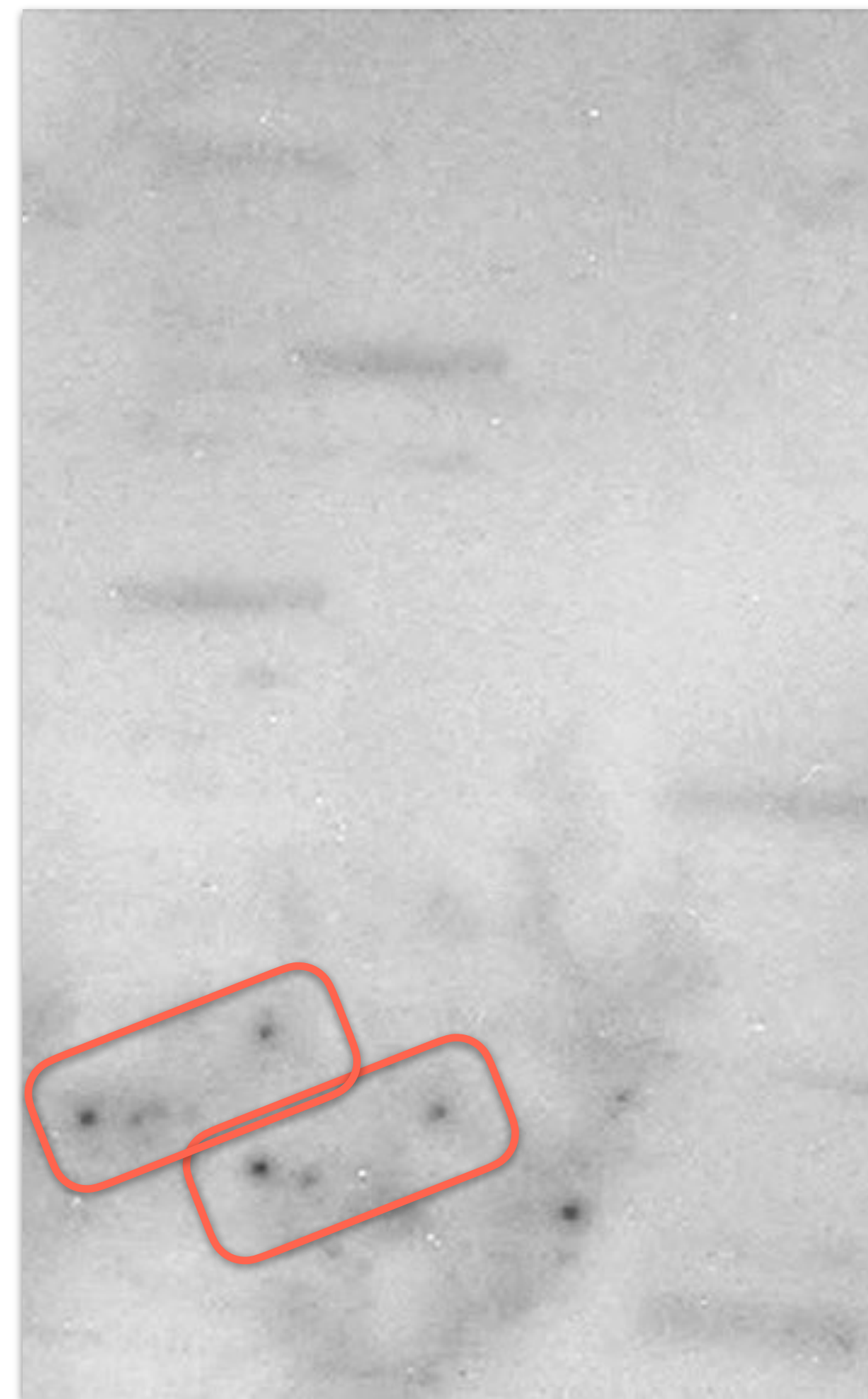
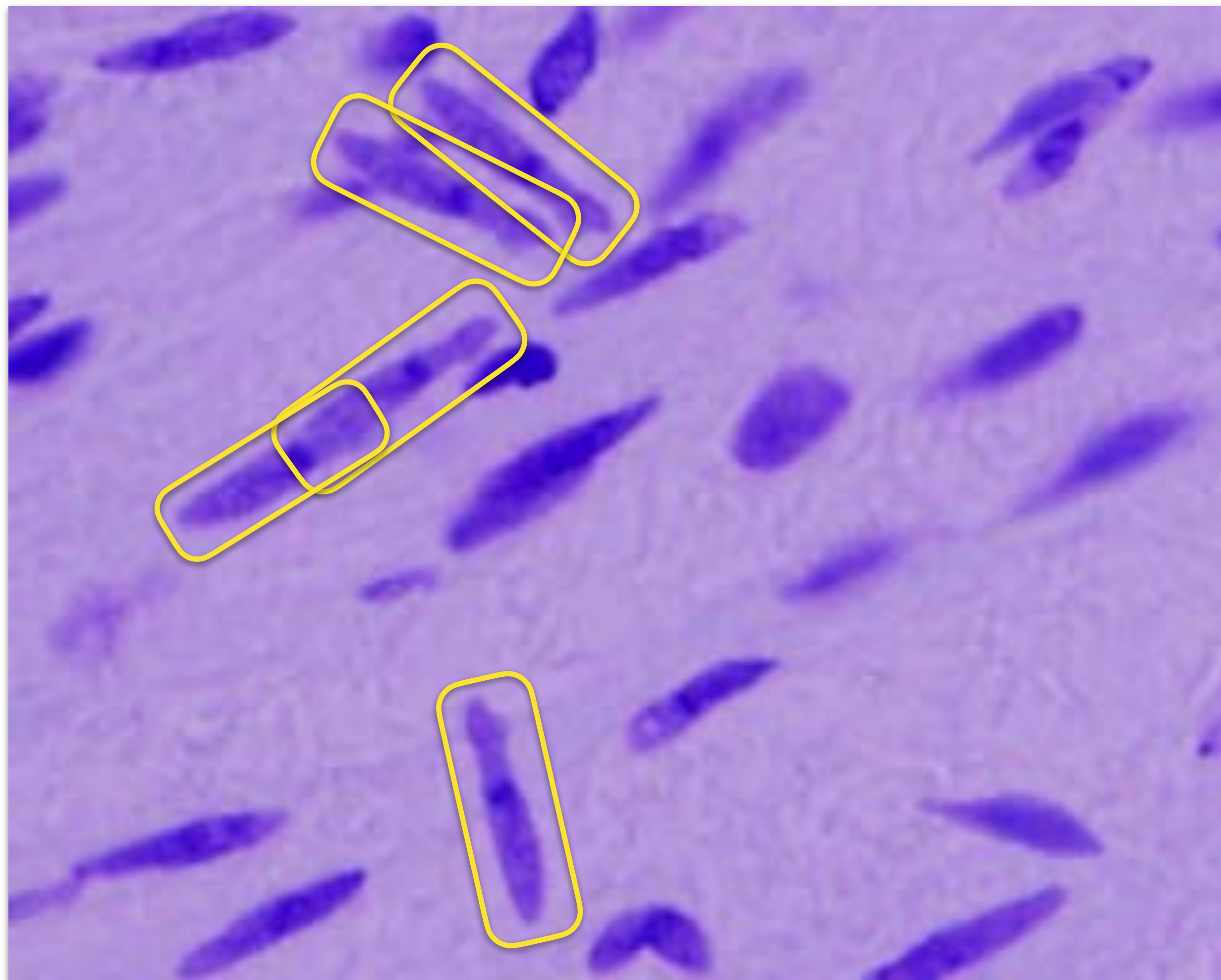
Copy-move detection over
real retracted data.

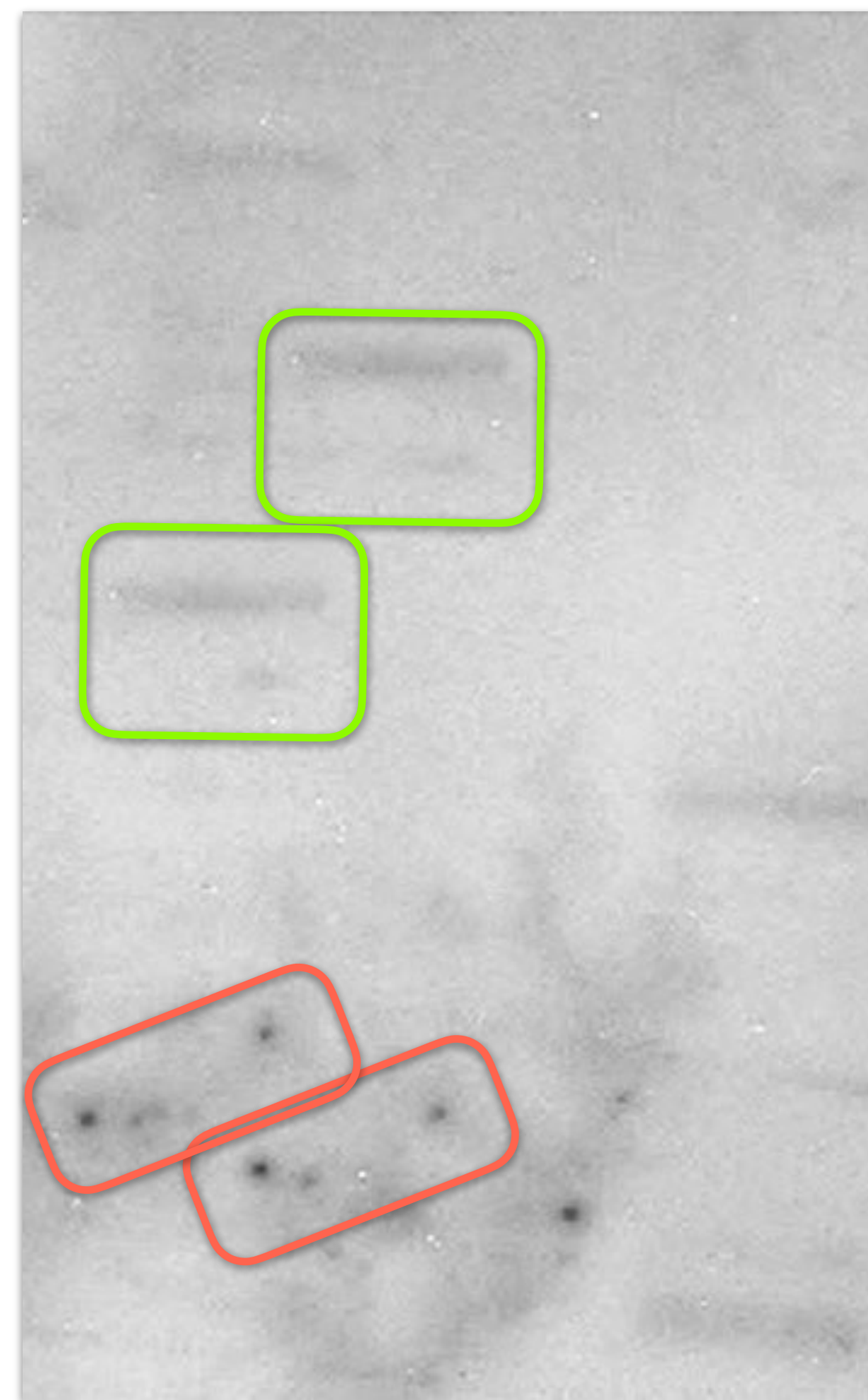
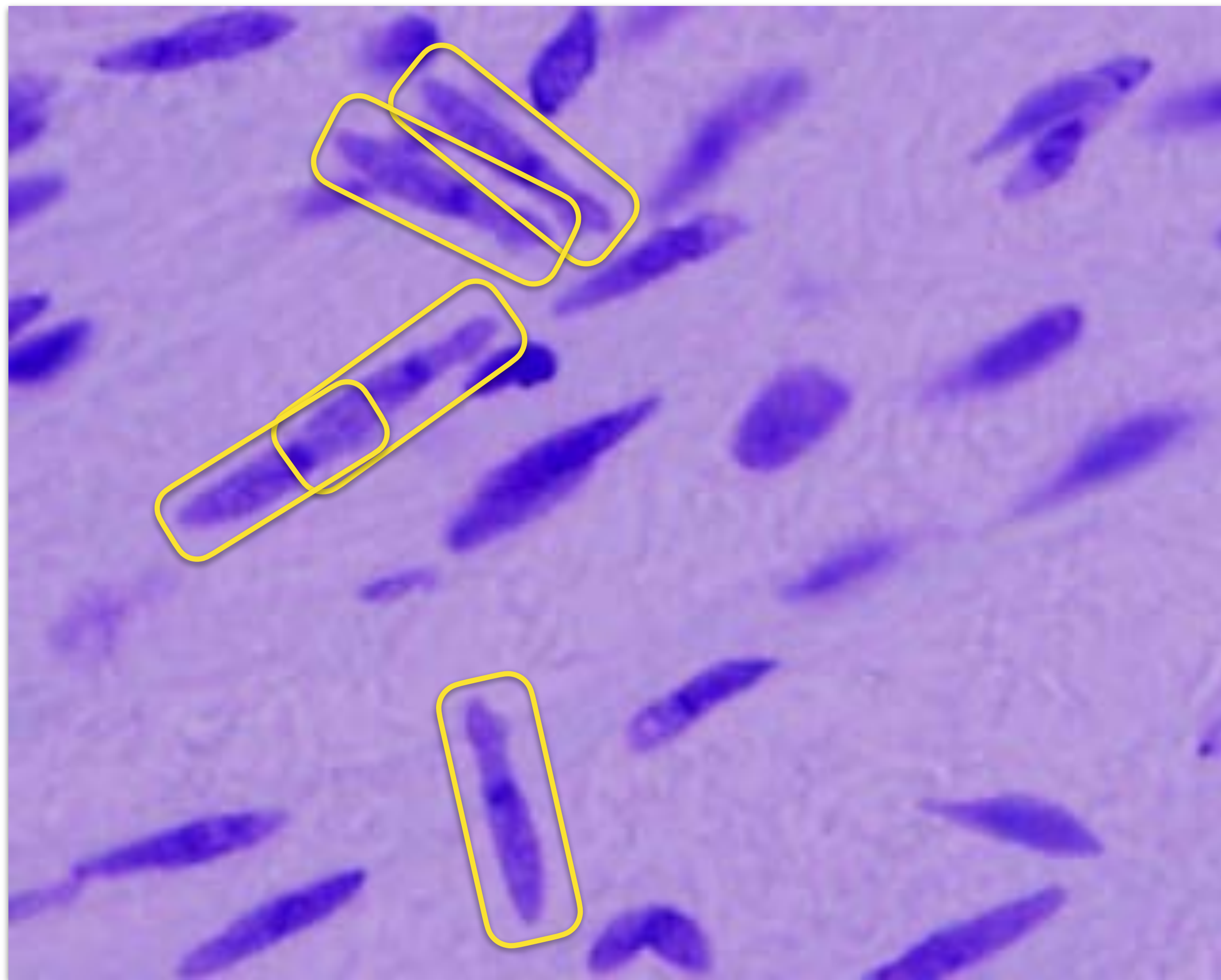


#	Team	Members	Score
1	Uladzislau Leketush		0.458
2	Guanshuo Xu		0.422
3	shiba-inu		0.394
4	BokingChen		0.391
5	qcf-568		0.388









Kaggle Competition

Scientific Image Forgery Detection

tinyurl.com/4zj9y62x

Copy-move detection over
real retracted data.

6 months

82 countries

25,000+ solution submissions

1,700+ competitors



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Kaggle Competition

Scientific Image Forgery Detection

tinyurl.com/4zj9y62x

Copy-move detection over
real retracted data.

6 months

82 countries

25,000+ solution submissions

1,700+ competitors

Baseline: 0.35 (pixel-wise F-score)

Winner: 0.46



#	Team	Members	Score
1	Uladzislau Leketush		0.458
2	Guanshuo Xu		0.422
3	shiba-inu		0.394
4	BokingChen		0.391
5	qcf-568		0.388

IEEE ICIP 2026



IEEE ICIP 2026



<https://sites.google.com/view/scifor-2026/home>

Tool Supporting the Human Examination of Post-Mortem Iris Images

<https://danielmoreira.github.io/project/tshepii/>



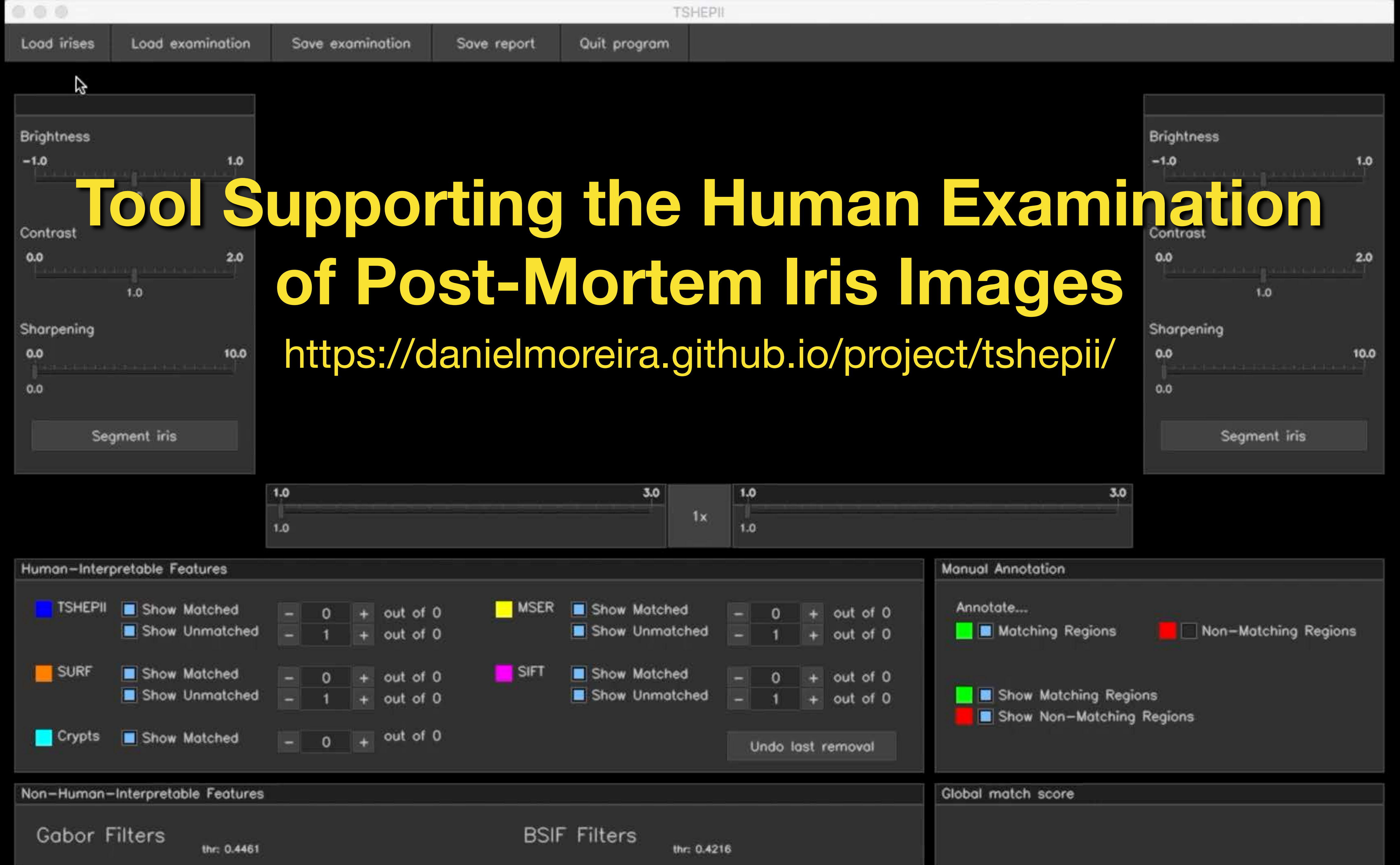
The Problem



Interpretable Iris Recognition



How to convince people who do not possess image processing expertise?

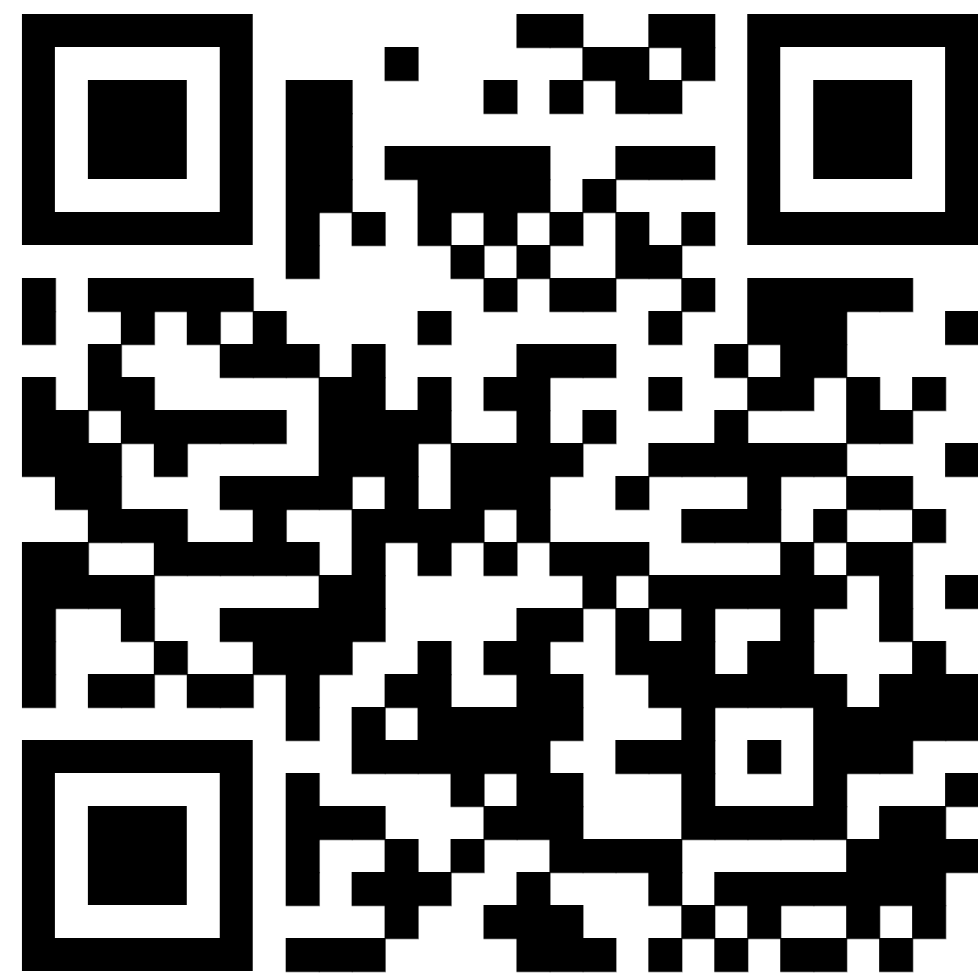


How about you?

Background

5 graduate and 2 undergraduate students

What is your major?



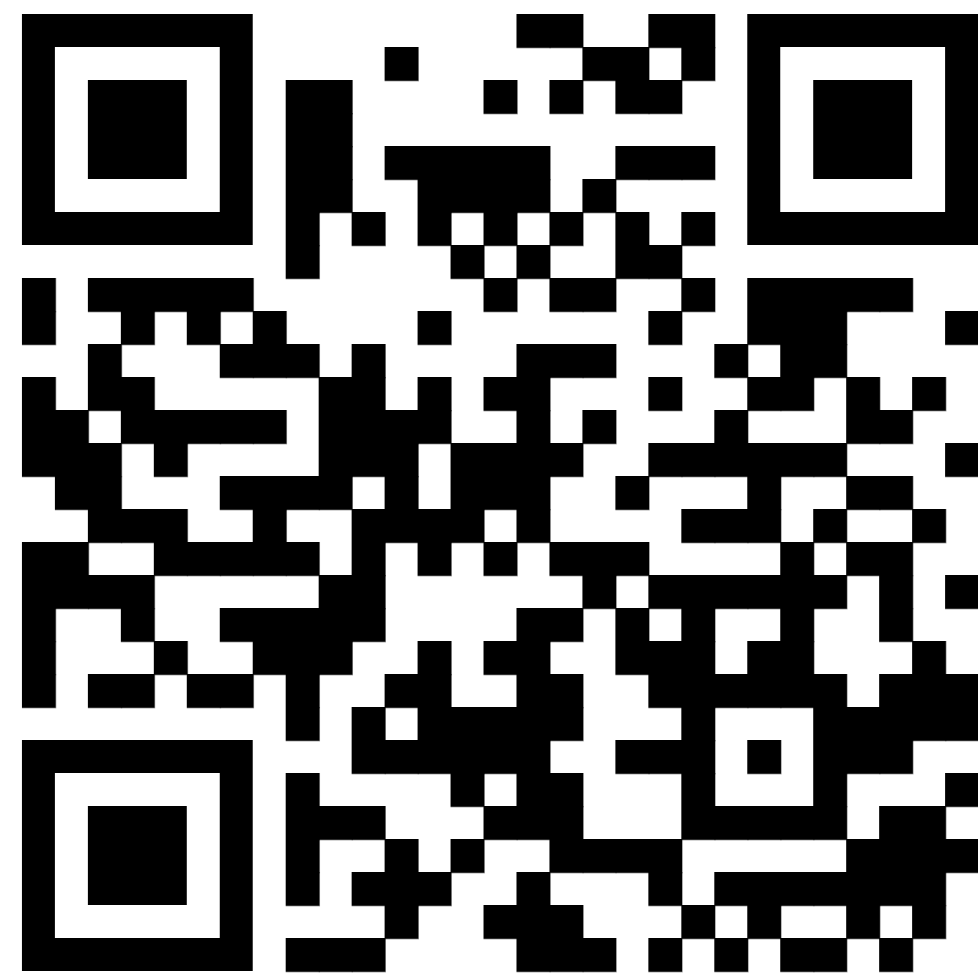
[forms.gle/
db2crFwq8QMttQ8A8](https://forms.gle/db2crFwq8QMttQ8A8)



How about you?

Expectations

Given your (future) career, what are your course expectations?



[forms.gle/
db2crFwq8QMttQ8A8](https://forms.gle/db2crFwq8QMttQ8A8)



How about you?

Accommodation Needs

Please reach out to me in private ASAP.
We'll make things work.



Today's Attendance

Please fill out the form

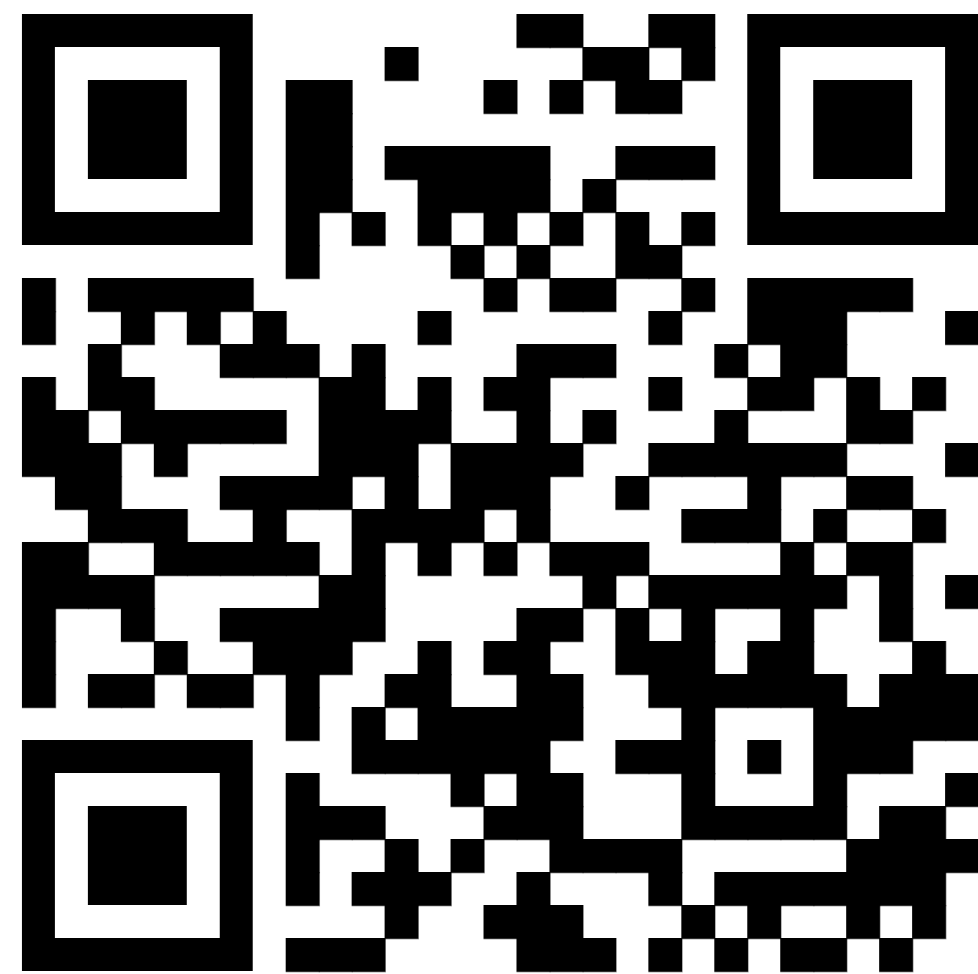
forms.gle/db2crFwq8QMttQ8A8



About the topic

Biometrics

What comes to your mind?



[forms.gle/
db2crFwq8QMttQ8A8](https://forms.gle/db2crFwq8QMttQ8A8)



What is Biometrics?



8.2 billion people

Who is this person?

Is this person Jane Doe?

What is Biometrics?



8.2 billion people

Who is this person? (*Identification*)

Is this person Jane Doe? (*Verification*)

What is Biometrics?



8.2 billion people

Who is this person? (*Identification*)

Is this person Jane Doe? (*Verification*)

Biometrics aims to *identify or verify* an individual's claimed identity based on their *physical, chemical, or behavioral* traits.

What is Biometrics?



In this course, we aim at **computer-aided Biometrics.**

We'll focus on **software solutions** rather than hardware.

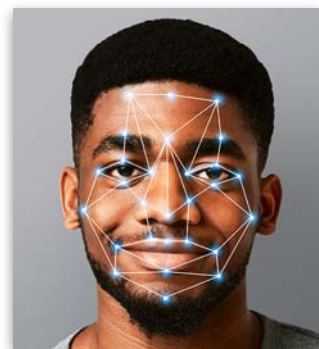
But we'll get to use some **devices**, I promise.

What is Biometrics?

Identity verification through:



A unique trait
of yours.



physical



chemical



behavioral



Not something
you **have**.



Not something
you **know**.



Why use Biometrics?

Consumers prefer biometric authentication to traditional passwords, Visa says

🕒 Jan 6, 2020 | [Chris Burt](#)

CATEGORIES [Biometrics News](#) | [Financial Services](#)

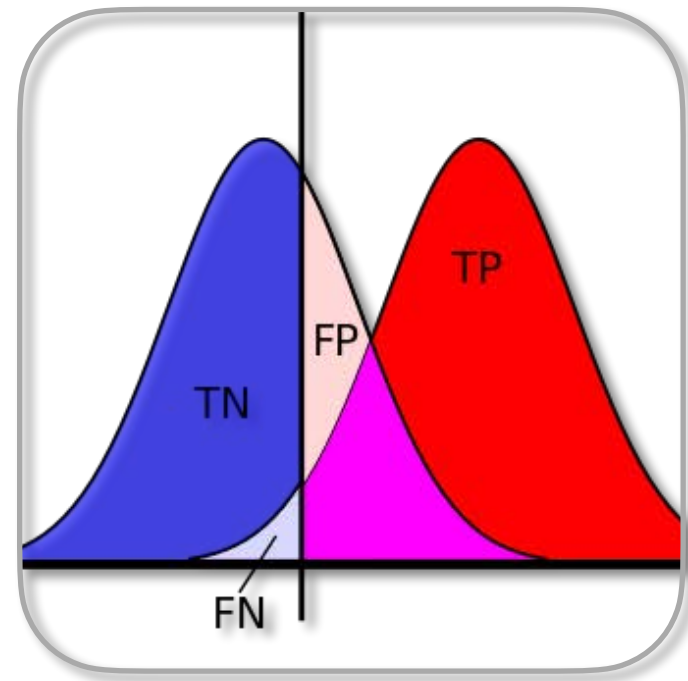


Almost 70 percent of U.S. shoppers did not go through with an online purchase because they either forgot the password, couldn't log in or couldn't receive a one-time passcode, according to research conducted by [Visa](#), while another report from Verizon found that as many as 80 percent of data breaches are caused by compromised and weak passwords.

<https://www.biometricupdate.com/202001/consumers-prefer-biometric-authentication-to-traditional-passwords-visa-says>

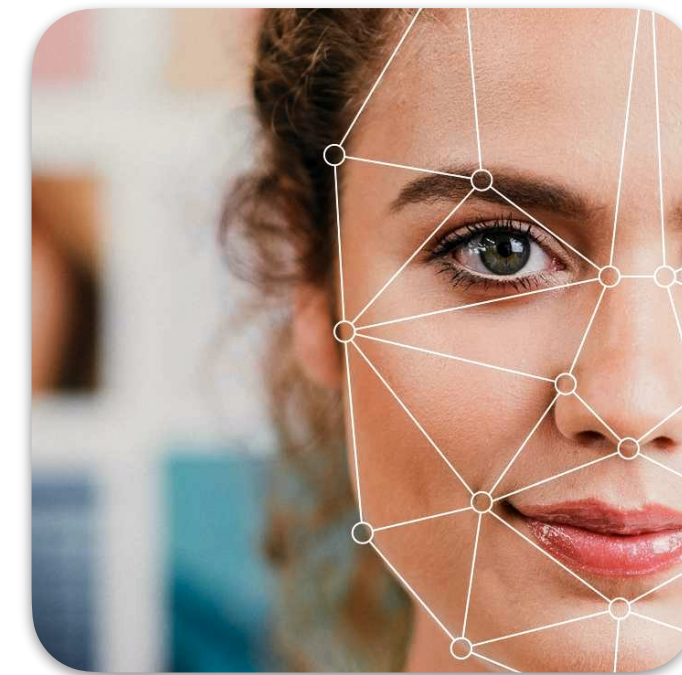
Course Overview

Content



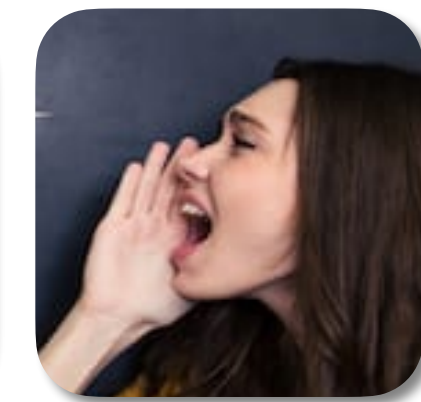
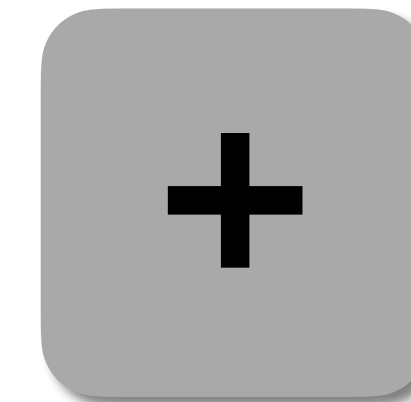
Basics

Concepts
Metrics
Metric
implementation



Core Traits (3)

Concepts
Baseline implementation
Data collection
Evaluation
Attacks
Assignments



**Alternative Traits and
Fusion
Concepts**



Invited Talks (2)
State of the art
Future work



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Course Overview

Structure *(tentative)*

23 lectures

4 in-class coding days with data collection

2 invited talks

Workload

4 assignments

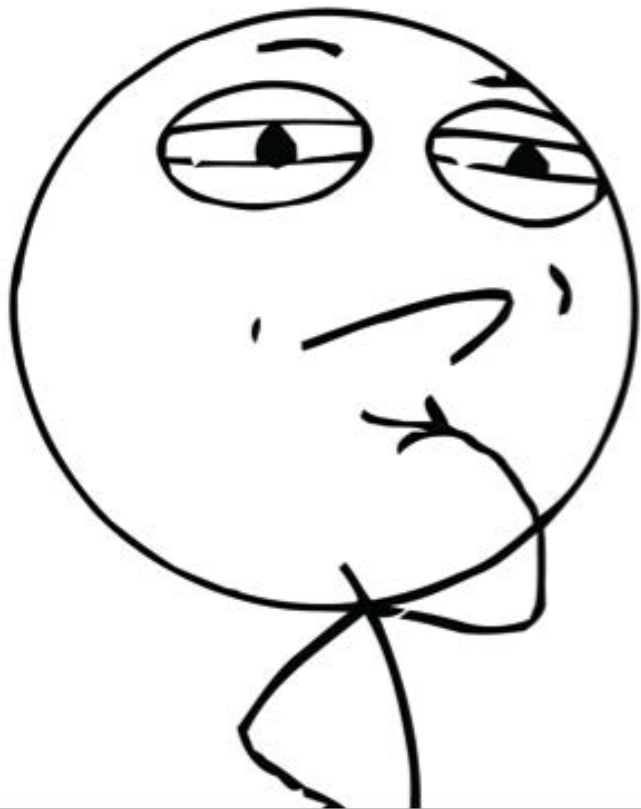
2 exams (midterm and final)

1 project with written report and presentation



Course Overview

CHALLENGE CONSIDERED



Schedule

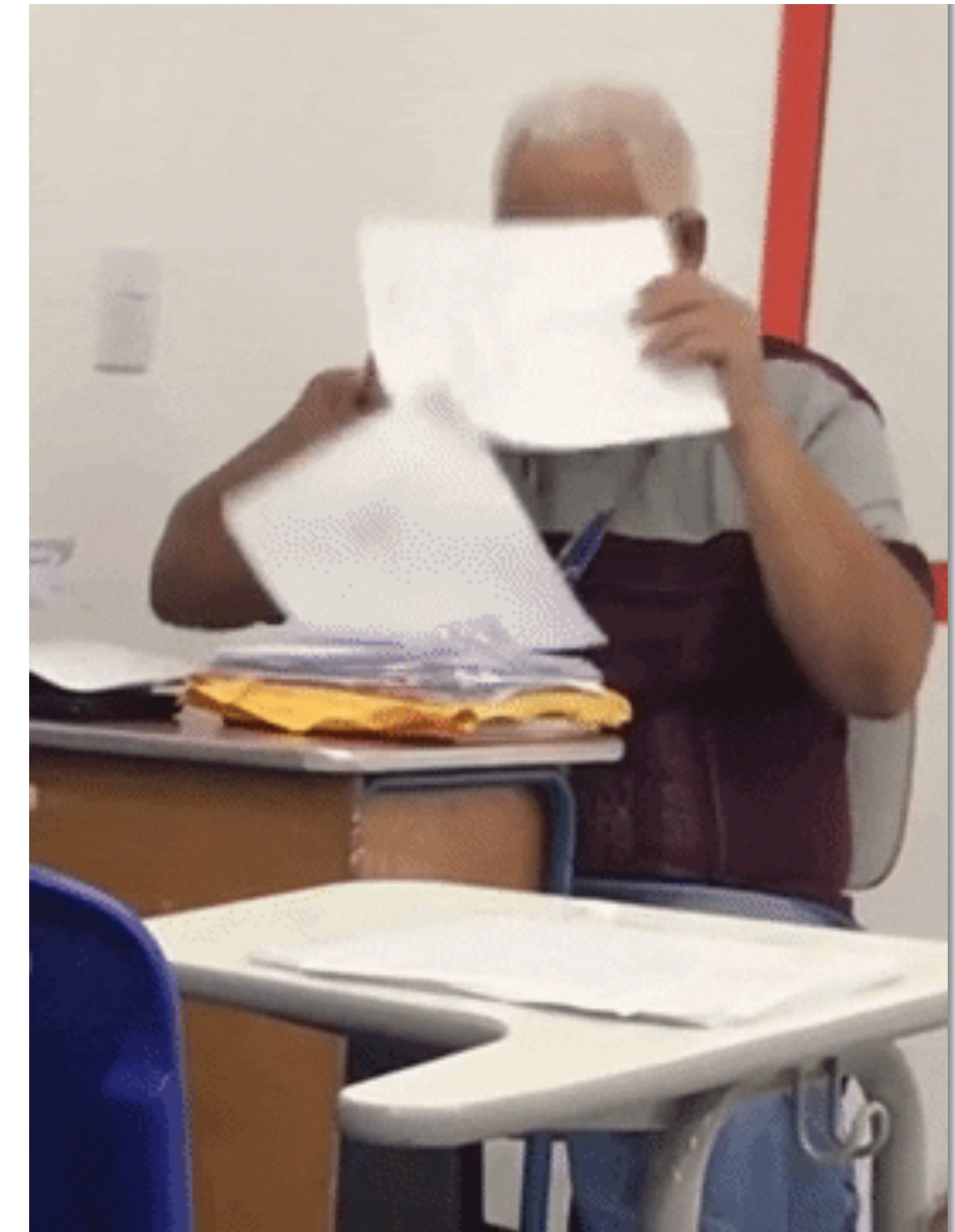
- 08/25 - Syllabus, Course details.
- 08/27 - Basics I, Biometrics, traits, and systems.
- 09/01 - Basics II, Biometric systems, errors, and metrics.
- 09/03 - 1st Coding Class, Metrics' implementation.
- 09/08 - Fingerprint Recog. I, History and features.
- 09/10 - Fingerprint Recog. II, Acquisition and enhancement.
- 09/15 - Reading Activity, *No sync class*.
- 09/17 - Fingerprint Recog. III, Minutiae detection.
- 09/22 - Fingerprint Recog. IV, Data collection.
- 09/24 - 2nd Coding Class, Fingerprint recognition.
- 09/29 - Midterm Preparation, Recap, and project discussion.
- 10/01 - Midterm Exam, *More soon*.
- 10/06 - Fall Break, *No classes*.
- 10/08 - Face Recog. I, Why faces and faces vs. other traits.
- 10/13 - Face Recog. II, Acquisition and enhancement.
- 10/15 - Face Recog. III, Description and matching.
- 10/20 - Face Recog. IV, Deep learning face recognition.
- 10/22 - 3rd Coding Class, Face recognition.
- 10/27 - Iris Recog. I, Why irises and irises vs. other traits.
- 10/29 - Iris Recog. II, Acquisition and enhancement.
- 11/03 - Iris Recog. III, Description and matching.
- 11/05 - 4th Coding Class, Iris recognition.
- 11/10 - Other Traits, Alternative traits and Soft Biometrics.
- 11/12 - Multibiometrics, Data fusion.
- 11/17 - Feature Indexing, Index building and feature querying.
- 11/19 - 1st Invited Talk, *More soon*.
- 11/24 - 2nd Invited Talk, *More soon*.
- 11/26 - Thanksgiving, *No classes*.
- 12/01 - Project Presentations I, *Show time*.
- 12/03 - Project Presentations II, *Show time*.
- 12/08 - Final Exam, *More soon*.

Course Overview

Grading

	Undergraduate	Graduate
Assignments (4)	40%	25%
Exams (2)	50%	40%
Project	10% (extra)	25%
Participation	10%	10%
On the News	1% (extra)	1% (extra)

A [96, 100)	B+ [88, 92)	C+ [76, 80)	D+ [64, 68)
A- [92, 96)	B [84, 88)	C [72, 76)	D [60, 64)
	B- [80, 84)	C- [68, 72)	F (0, 60)

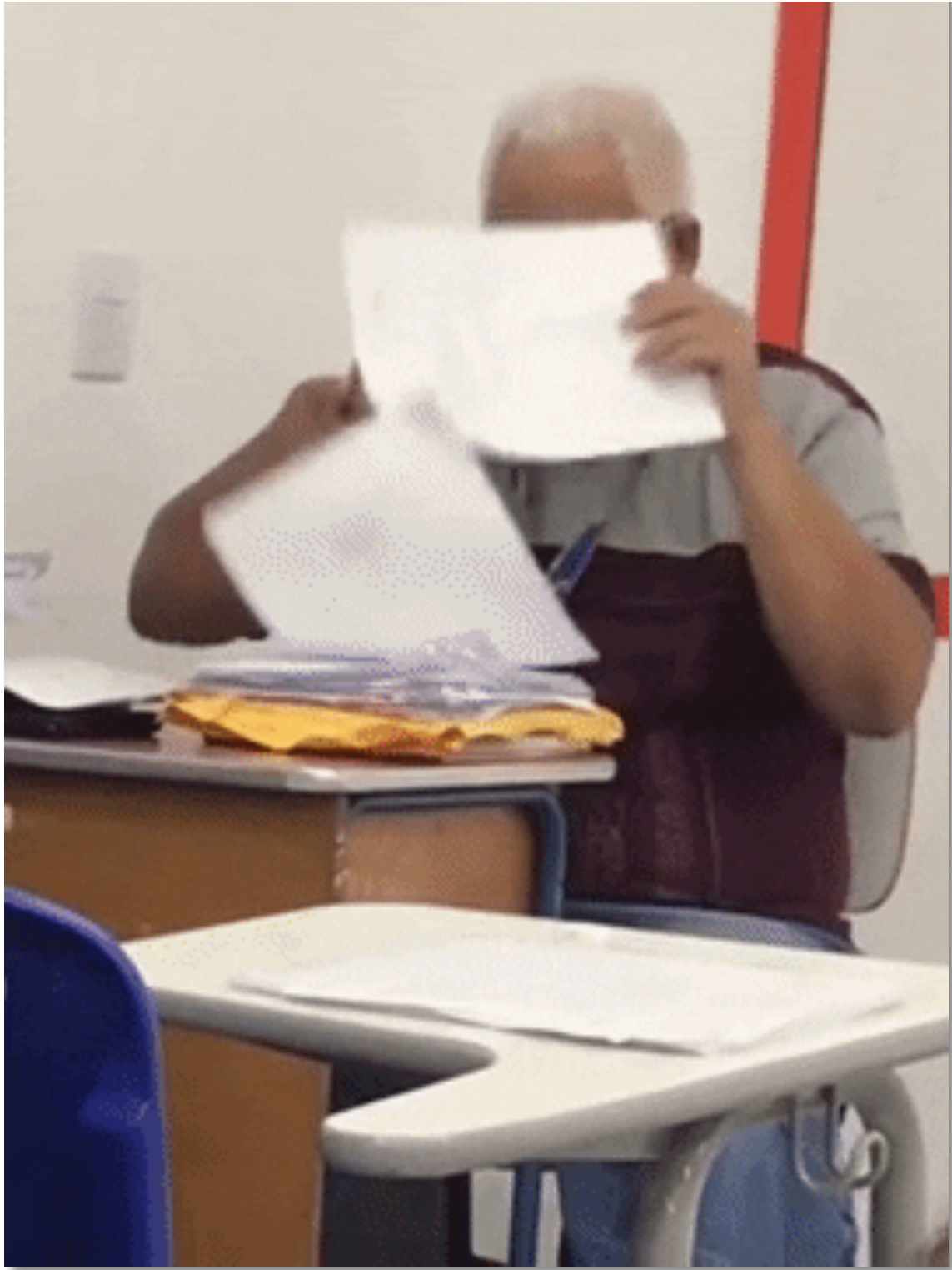


Course Overview

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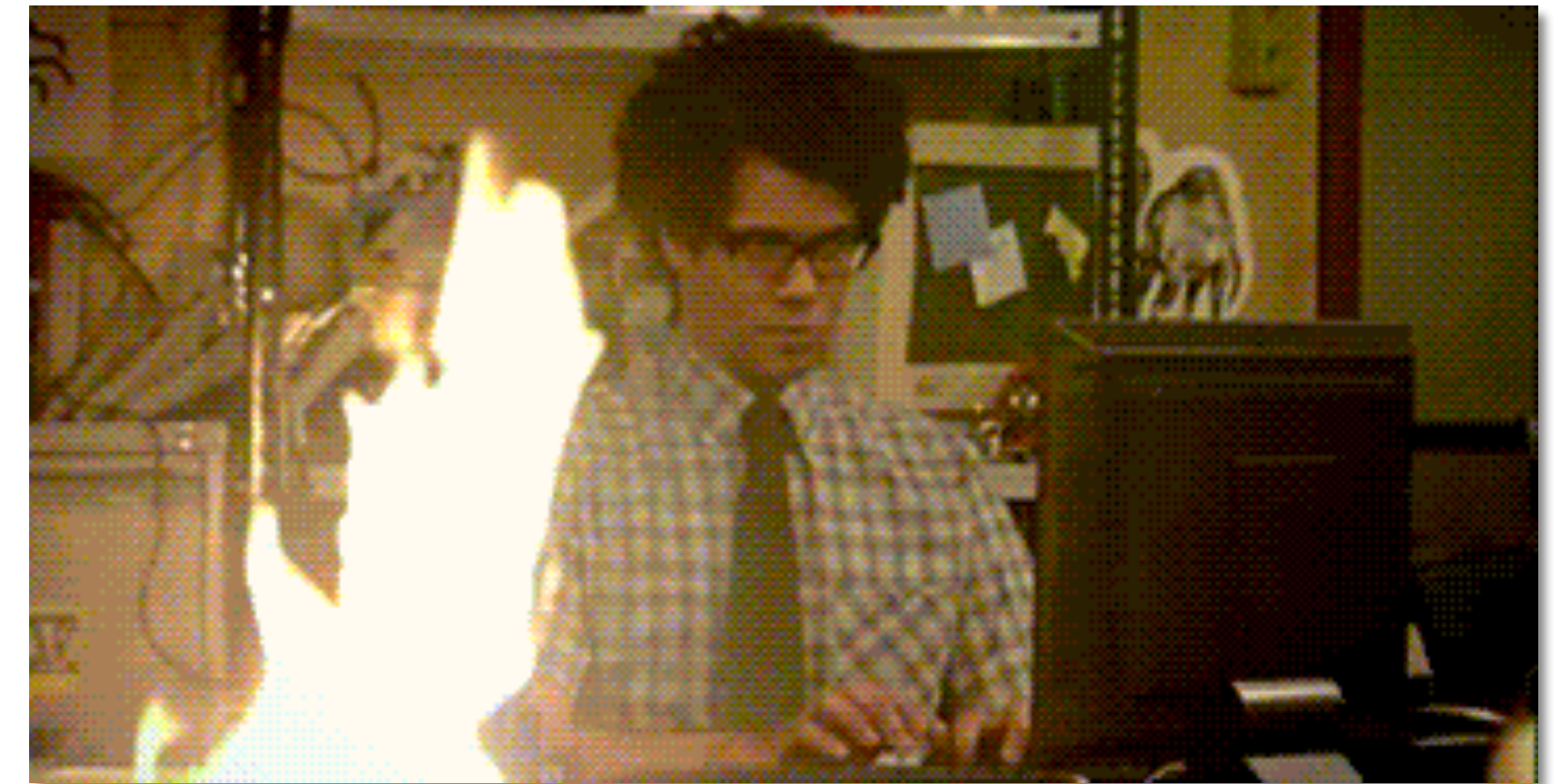
Course Overview

Assignments

Individual take-home activities

Submission through Sakai

Late policy: -10% of the maximum possible grade for each day of delay.



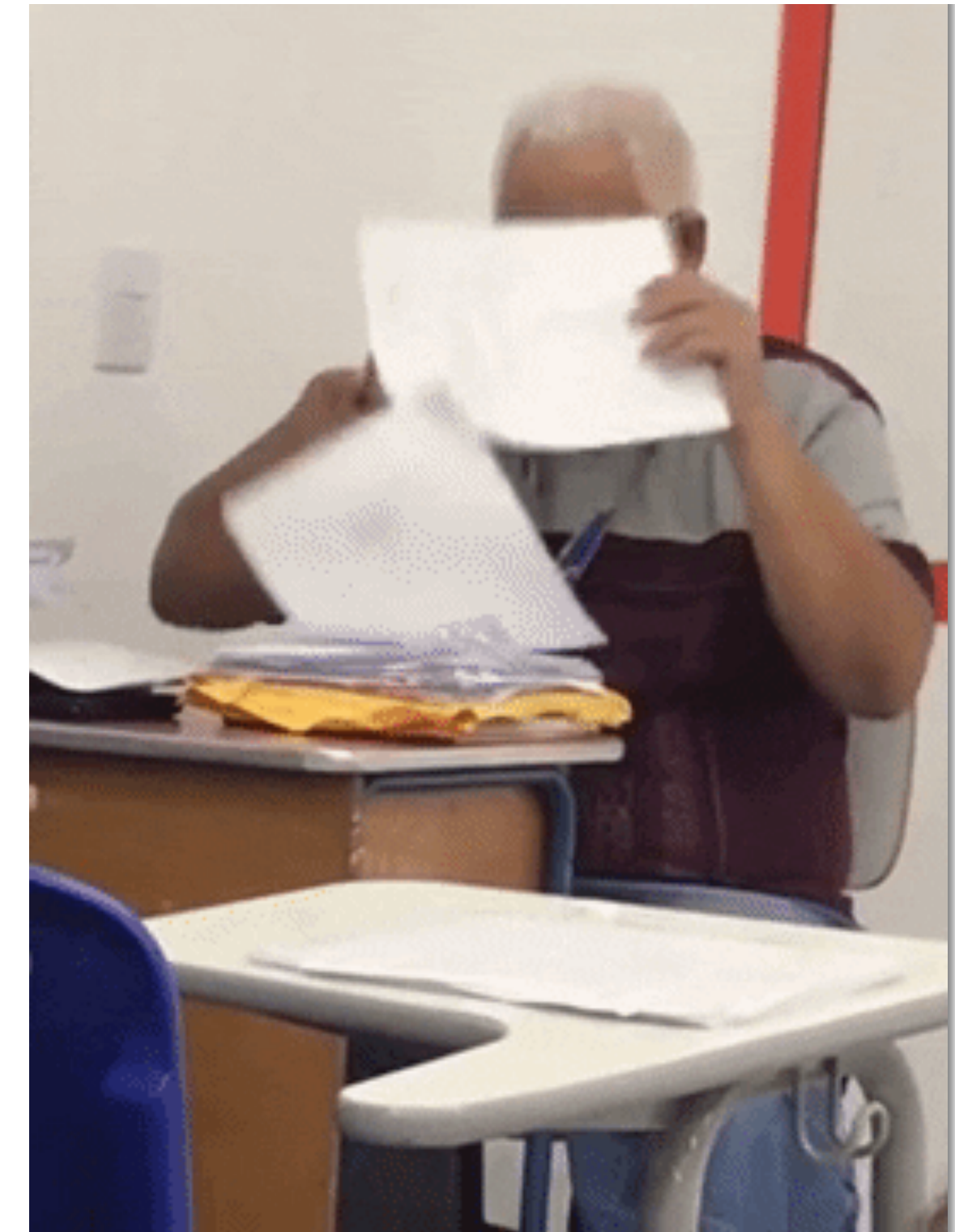
Assignment 1	Assignment 2	Assignment 3	Assignment 4
Metric Collection	Fingerprint Recognition	Face Recognition	Iris Recognition

Course Overview

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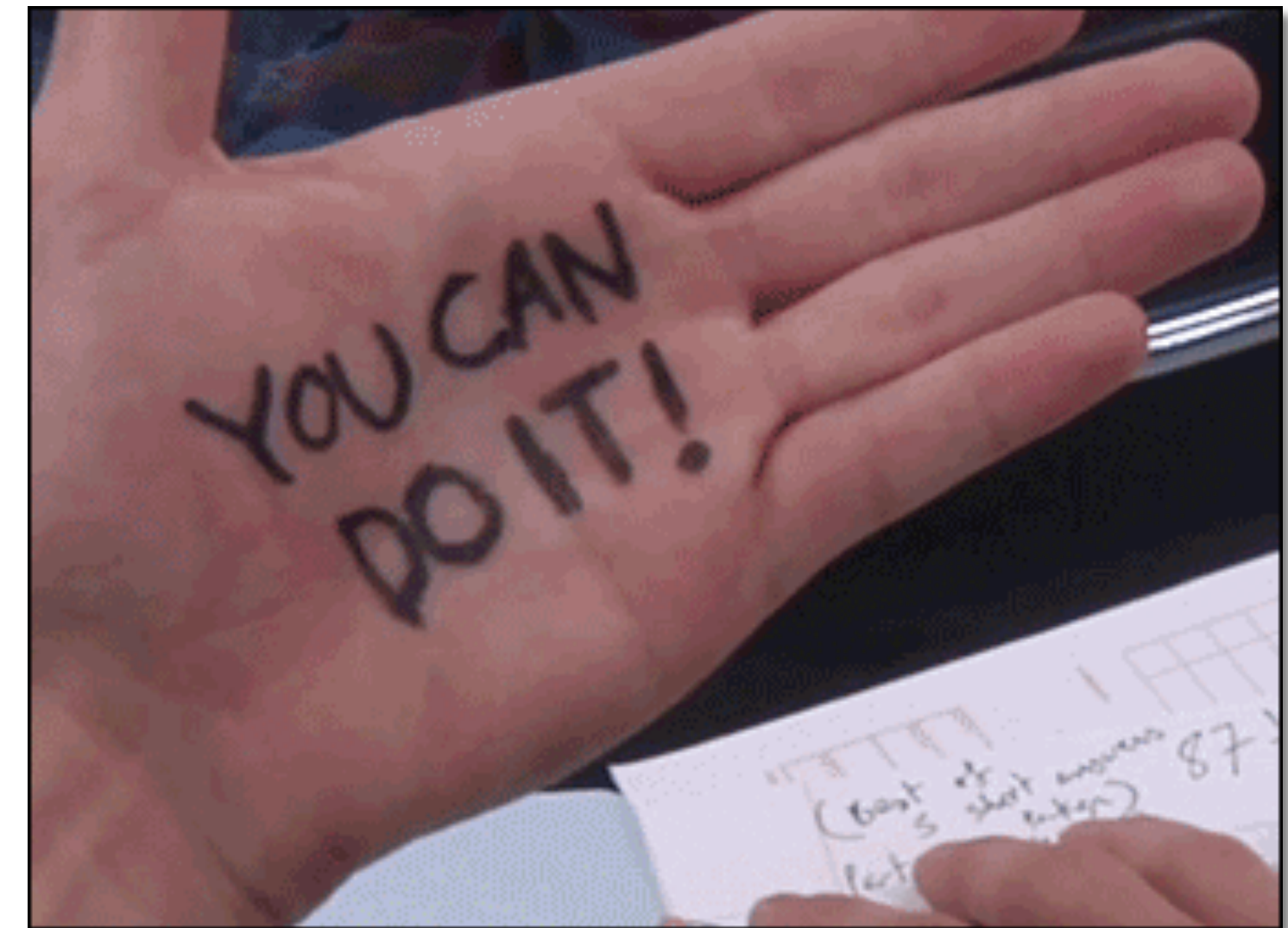
Course Overview

Exams

10/01: in-class written midterm

12/08: in-class written final

One-page cheat sheet is allowed.



Course Overview

Exams

Style example.

[Question 1] (2 points)

Suppose you were hired by a bank company to coordinate the deployment of an access management system to control the entrance of authorized people into the many vaults spread among different branches. The bank directors have heard about Biometrics but are not certain about the benefits of using it. They think using simple access cards and long passwords is as effective and much cheaper than using a biometric system. If it is your duty to change their mind, **what would you say to convince them?**

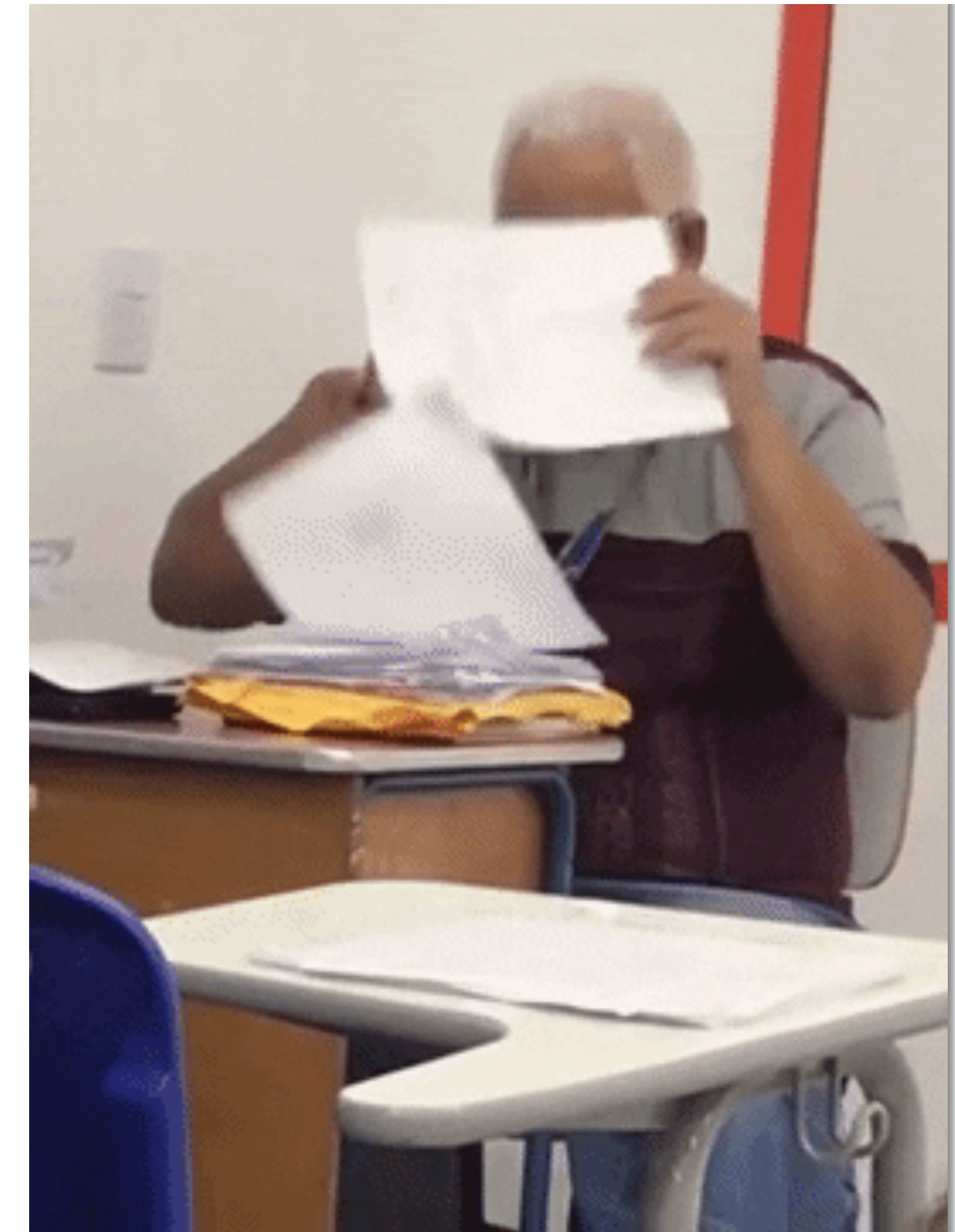
Using biometrics would be a much safer system, since it uses a physical or chemical trait, rather than something that can be stolen as easily as an access card. A password could also be given to somebody else or brute force searched to produce attacks. Furthermore, it would be more convenient for the authorized people, as forgetting a long password or losing an access card would not be a problem. (Biometrics uses a trait you always have on you). Also, problems like typos, and card damages are more likely to happen than losing a fingerprint, iris, or face.

Course Overview

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Course Overview

Project

Work alone or in groups.
Provide a written report and
perform a presentation.

Optional for undergraduate students
(it will grant extra points).



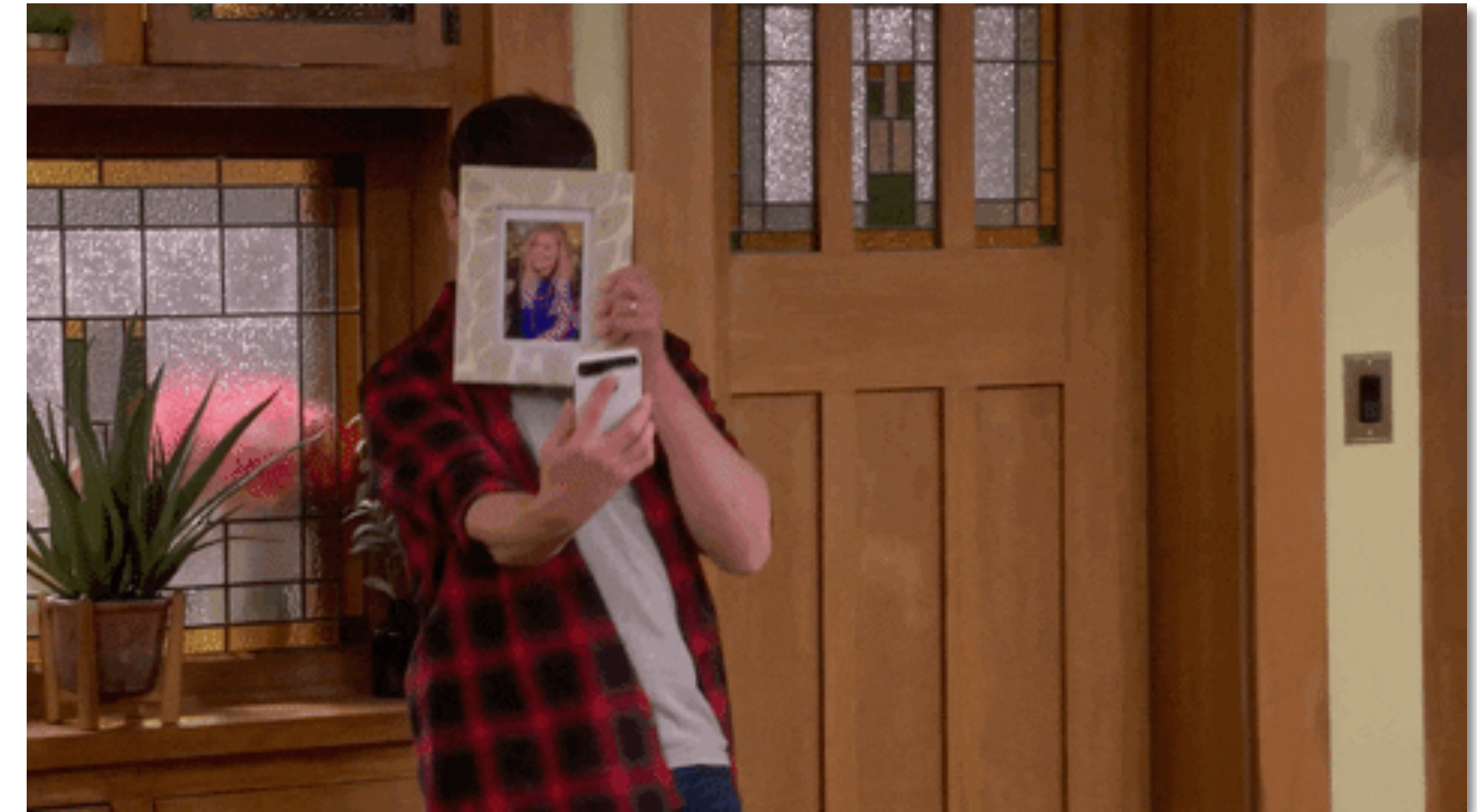
Course Overview

Project

Possible Topics

Presentation attack
(performance, detection, and mitigation)
of fingerprint, face, or iris recognition.

Implementation of recognition of traits
other than fingerprints, face, and iris.



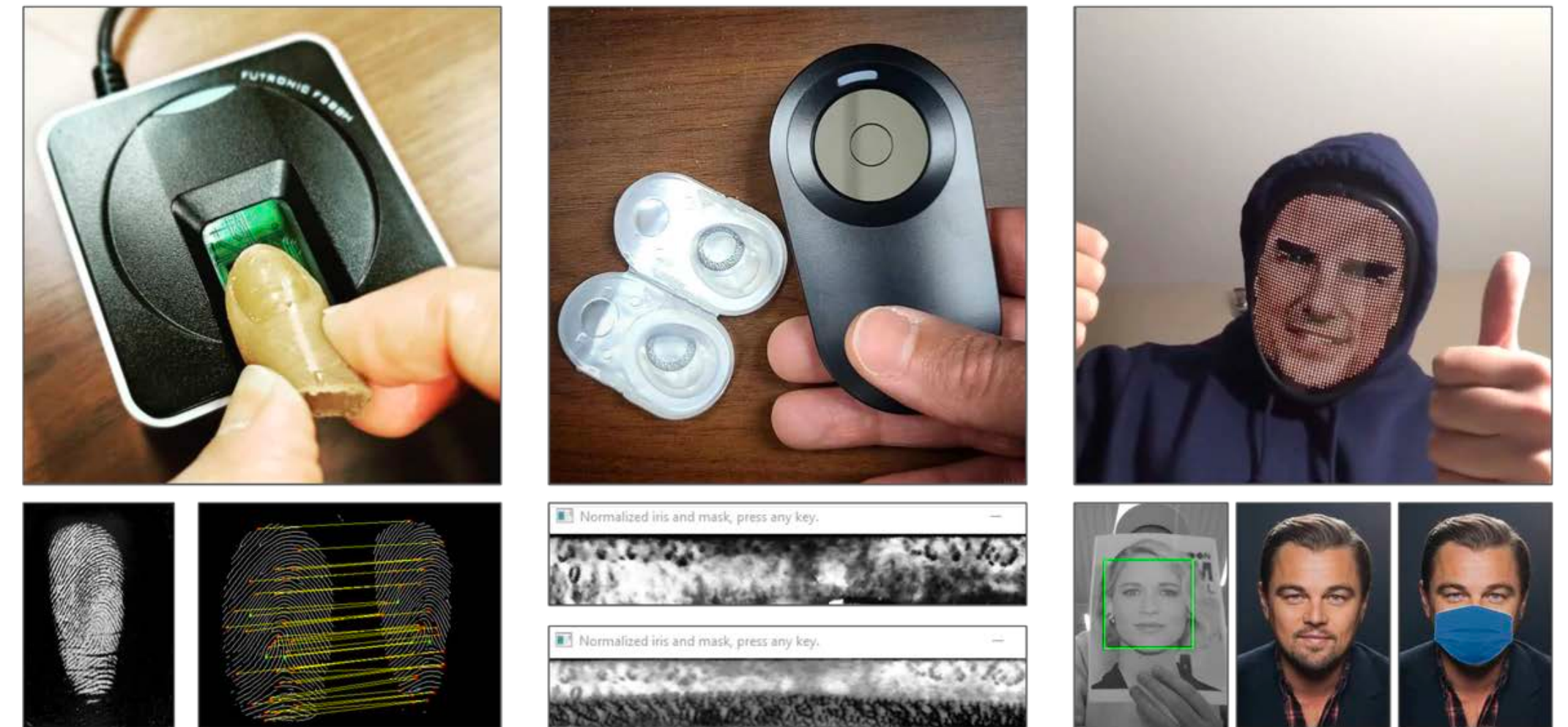
Course Overview

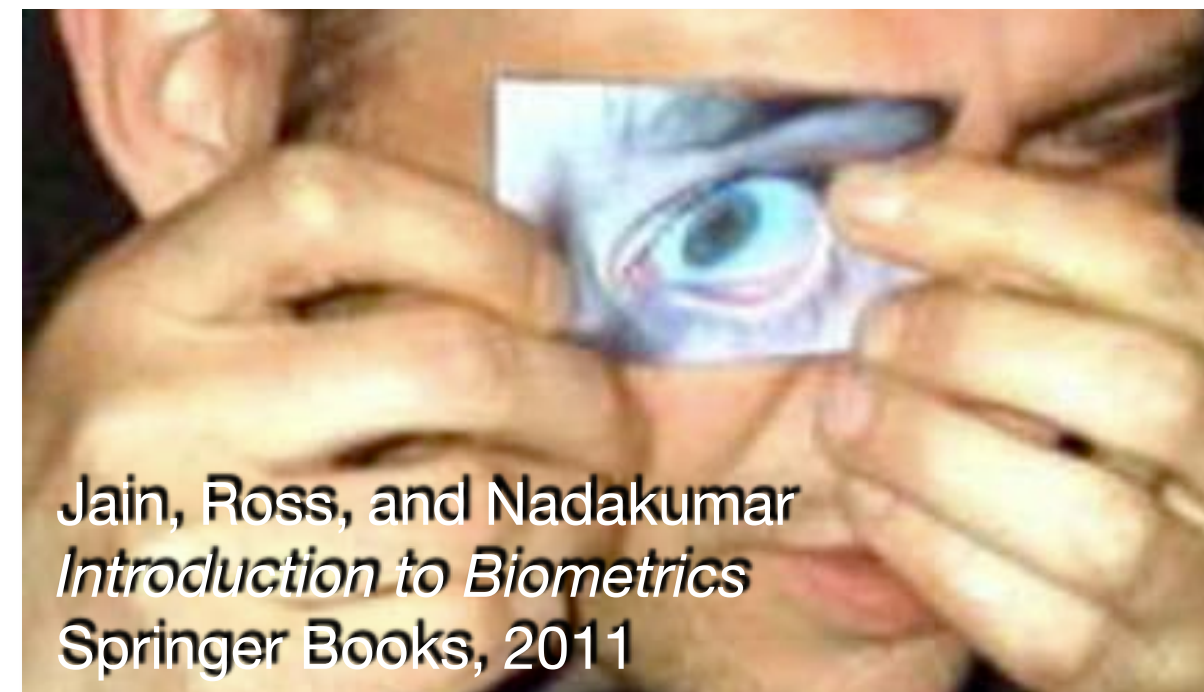
Project

Possible Topics *(continued)*
Implementation of a complete class attendance system.

Presentation and implementation of state-of-the-art scientific publications.

Discussion about the ethical aspects of Biometrics and surveillance.



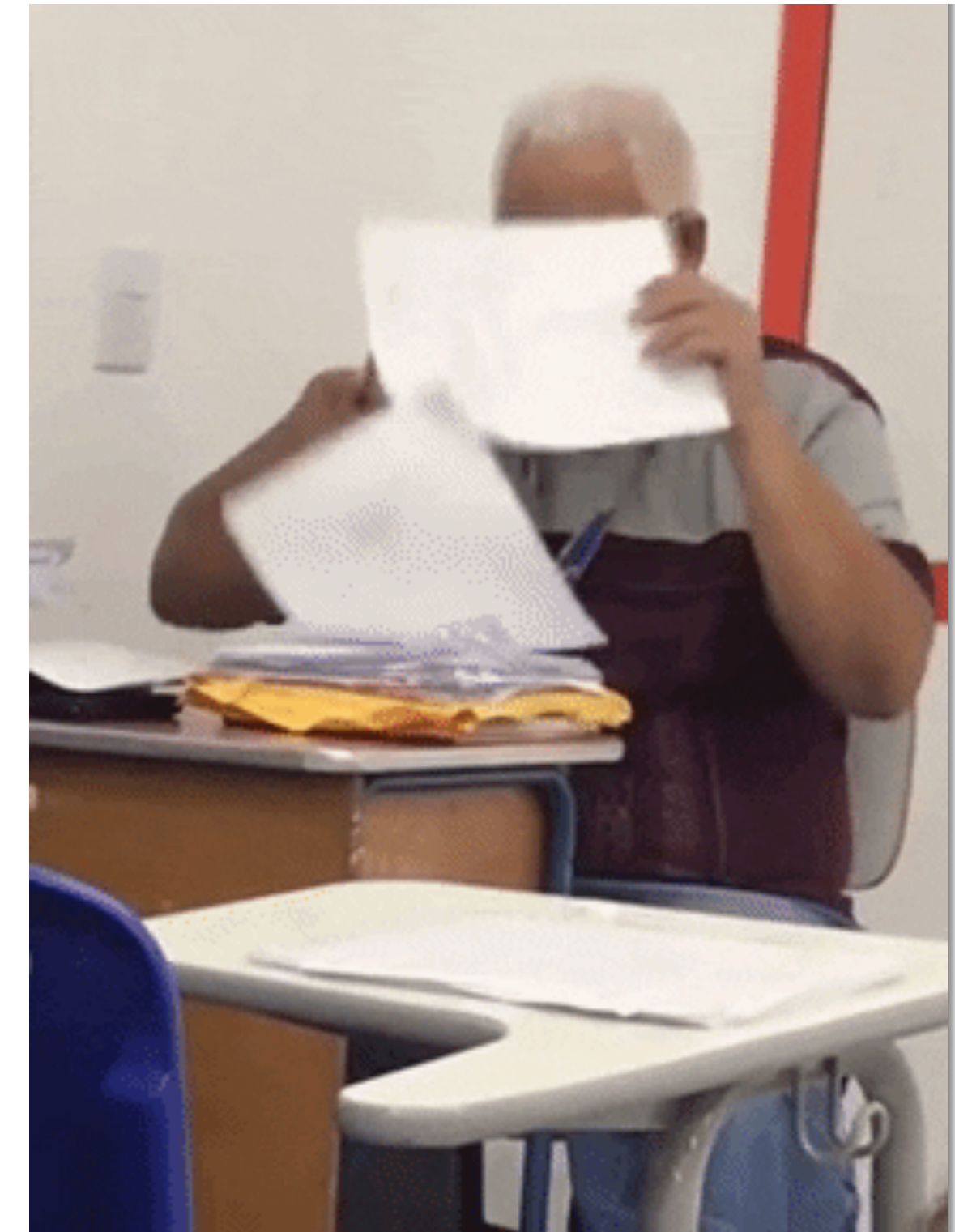


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Course Overview

Participation

Class Attendance

Every presence counts.

It is possible to get extra points based on interest and proactivity.



Course Overview

Participation

Today-I-missed Statements

Submit **on Sakai** after every class.

Answer one of

What is your biggest question after class?

or

What was the most interesting point you learned today?



Course Overview

Participation

Grace Cards

Life happens, each student has 3 cards.

Cards can be used to excuse absences or late-delivered work (up to 9 days of delay).

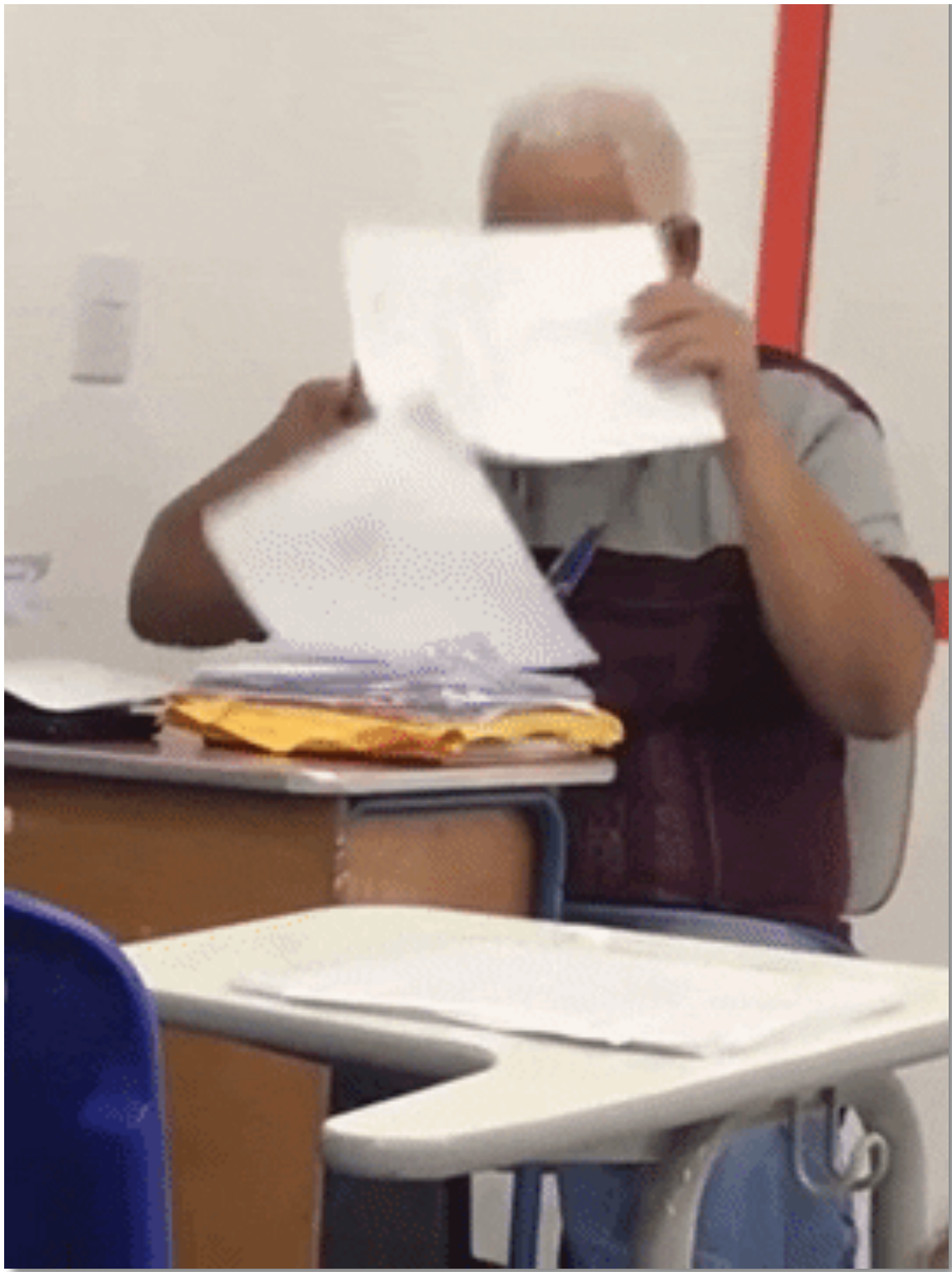


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	B- [80, 84)	C- [68, 72)	F (0, 60)



Course Overview

Biometrics on the News

Share with us news you find related to Biometrics.

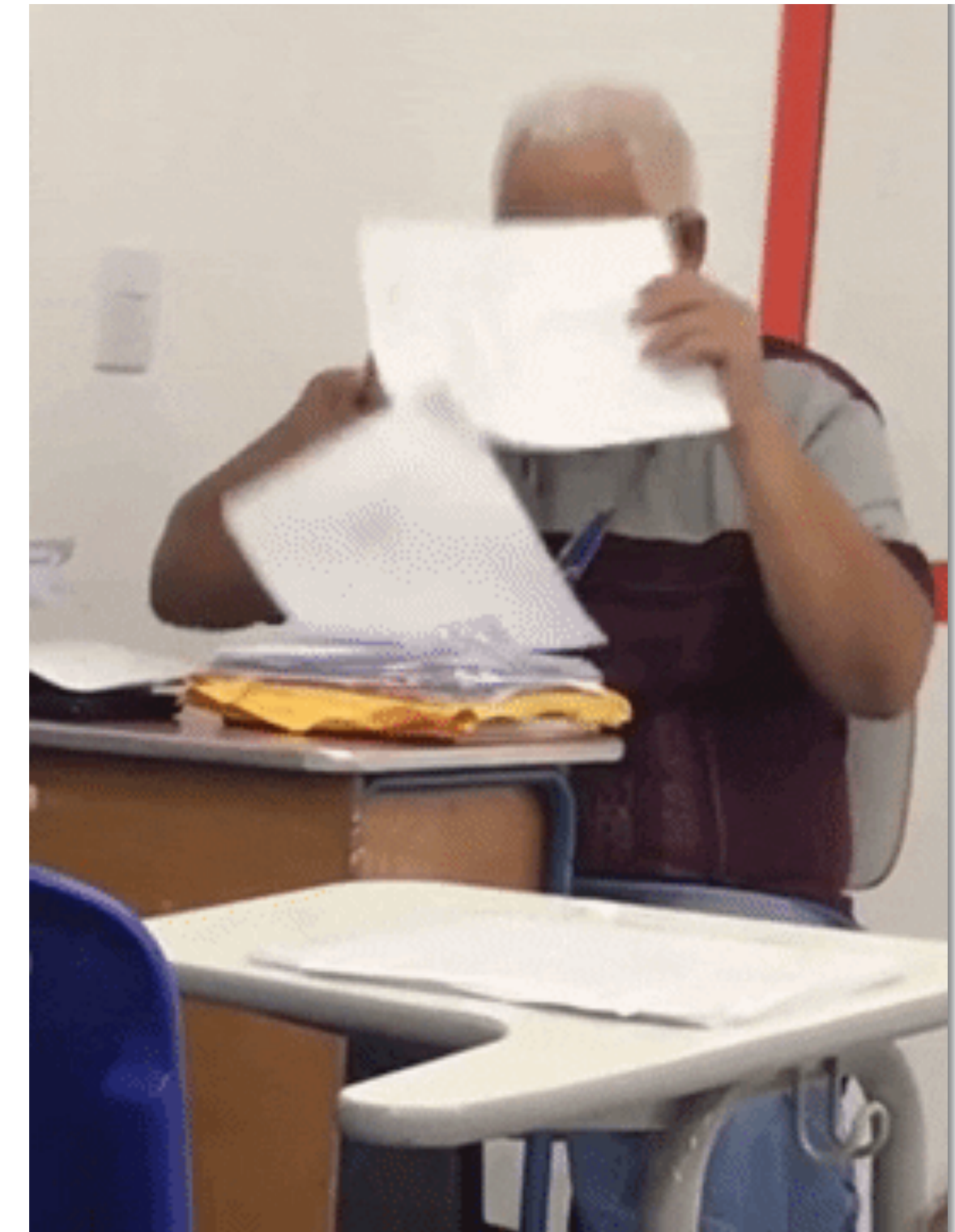
Get extra points for doing that.



Course Overview

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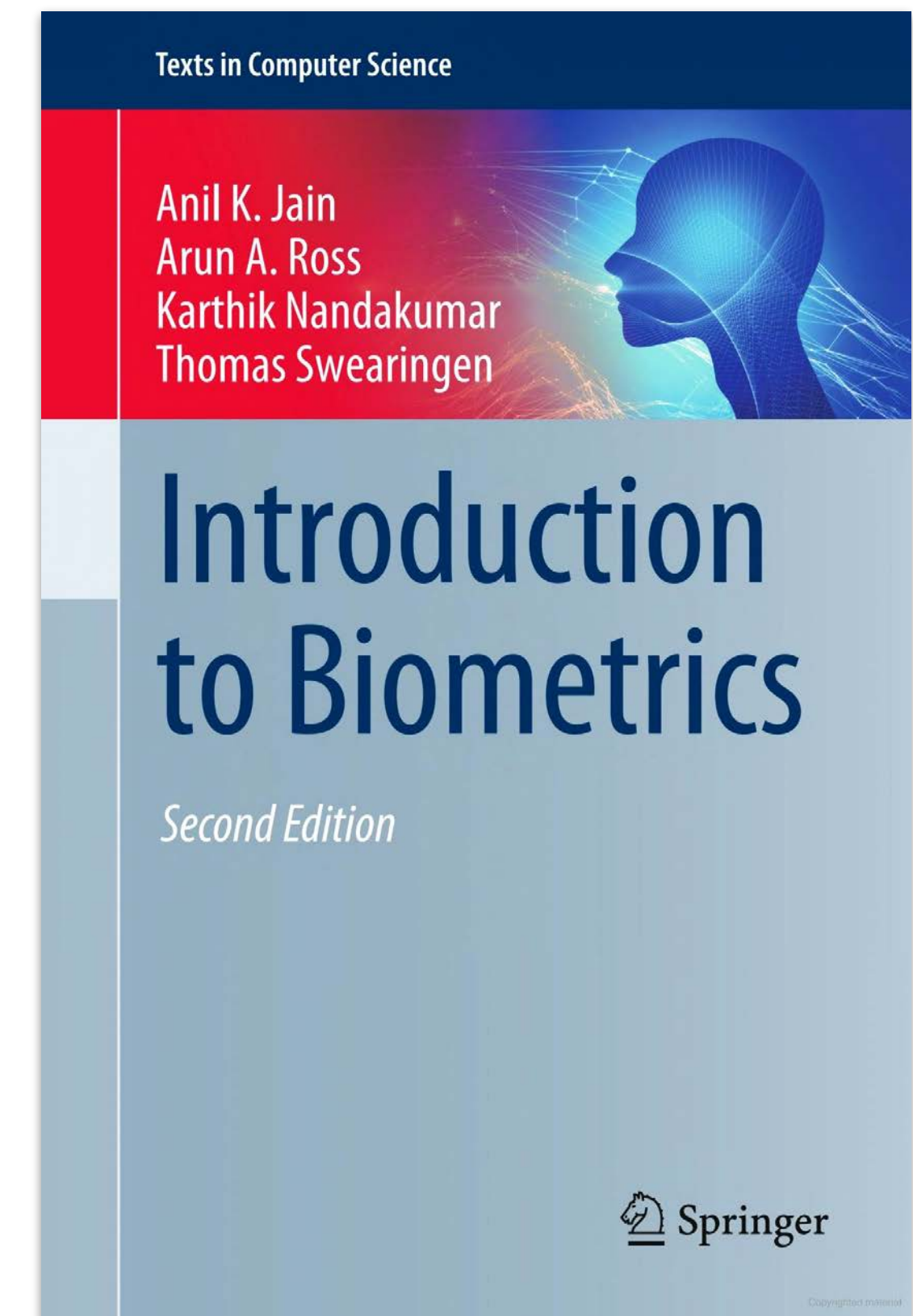
Code of Honor

Please refer to <https://tinyurl.com/25nvdbr8>.
Break it and get an F.

Course Overview

Bibliography

Jain, Ross, Nandakumar, and Swearingen
Introduction to Biometrics, 2nd Edition
Springer Books, 2025



Course Overview

Pre-requisites

Essential

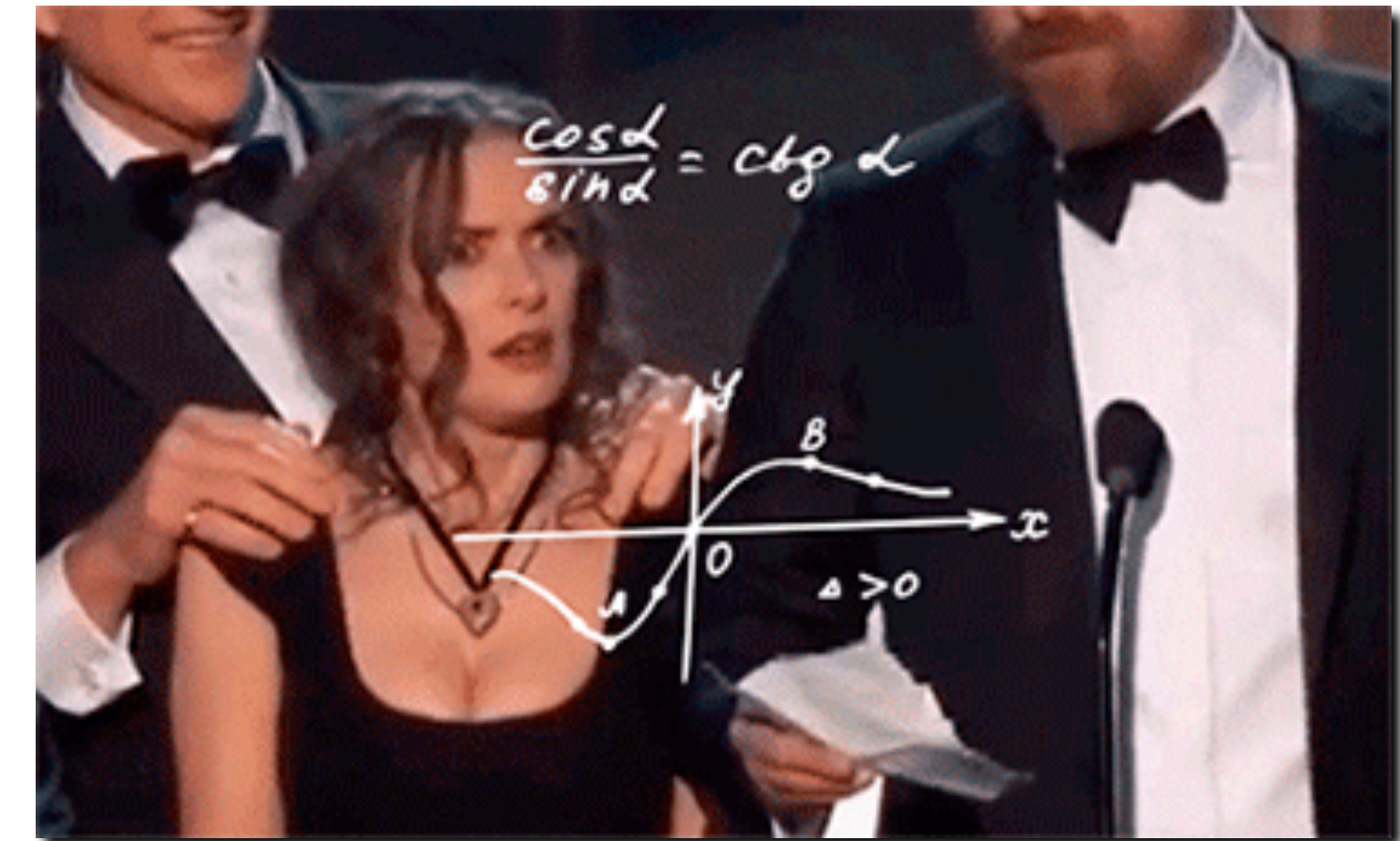
Programming, basic prob & stats,
and data structures

Desired

Python, Numpy, Matplotlib, and OpenCV

Not sure?

Please talk to me in private.



Course Overview

Data Collection

We'll collect only **our own biometric** data (instructor's and students').

Our data **will only be used** for the purpose of the course.

Our data **will not be shared** with anybody outside the course.

Our data **will be deleted** after the course.

During assignments, folks in need of other publicly available biometric databases are welcome to contact me, so we can take care of privacy and copyright issues.



Course Overview

Why Python?

High-level enough

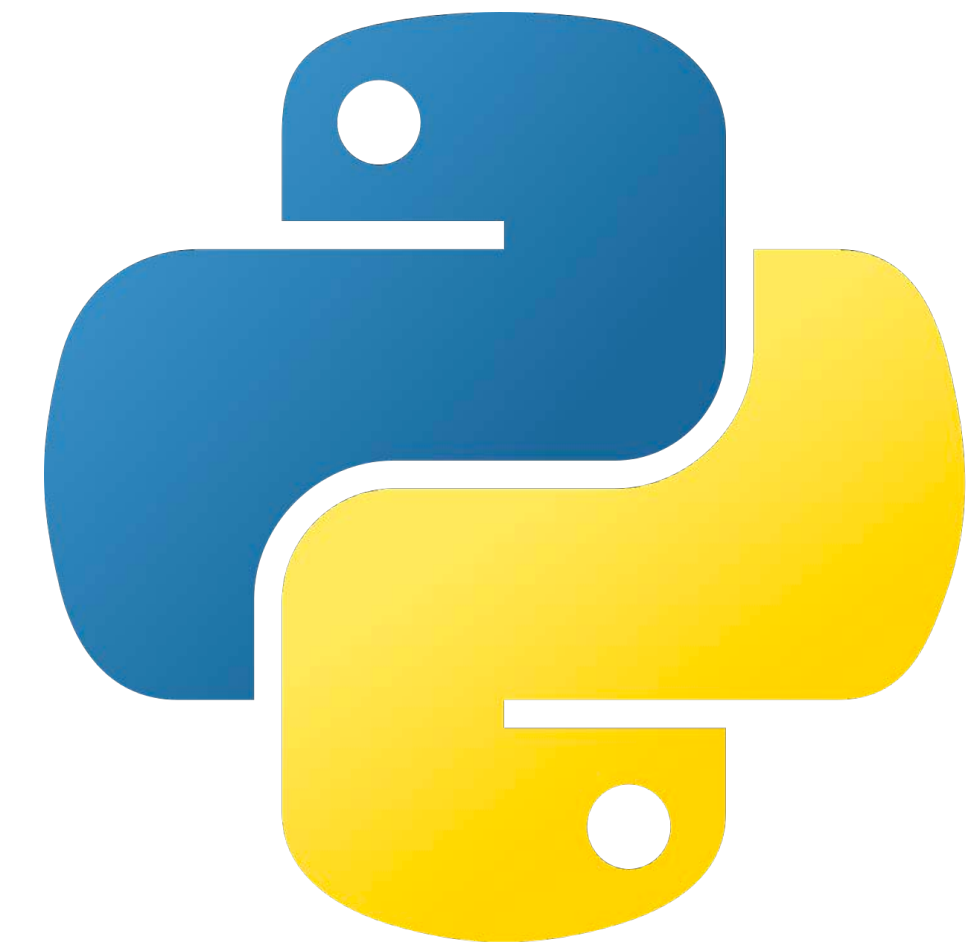
General-purpose enough

Good code readability

High productivity in data processing
(easy to manipulate strings, lists, and dictionaries).

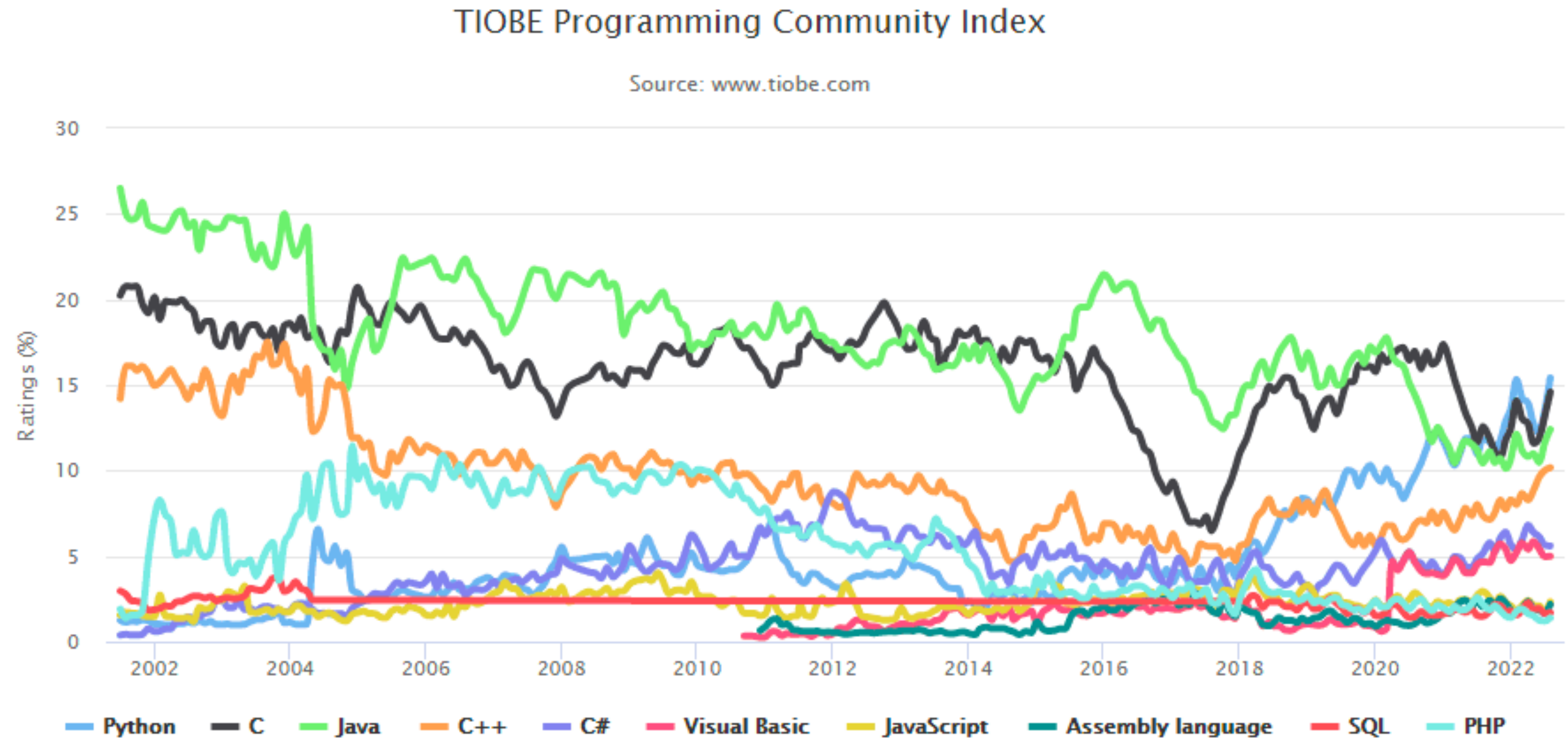
Large supporting community.

Good libraries supporting scientific computing
(e.g., Numpy, ScyPy, Matplotlib).



Course Overview

Why Python?
Increasing
popularity



Course Overview

Jupyter Notebooks

Interactive computing

Adoption of the *notebook* interface:
Multiple cells for (1) explanation,
(2) coding, and (3) output of results.



Course Overview

Jupyter Notebooks

explanation

coding

output

PyCon 2018: Using pandas for Better (and Worse) Data Science

GitHub: <https://github.com/justmarkham/pycon-2018-tutorial>

```
In [1]: import matplotlib.pyplot as plt
import pandas as pd
pd.__version__
```

```
Out[1]: '0.24.1'
```

Dataset: Stanford Open Policing Project ([video](#))

```
In [2]: # ri stands for Rhode Island
ri = pd.read_csv('police.csv')
```

```
In [3]: # what does each row represent?
ri.head()
```

```
Out[3]:
```

	stop_date	stop_time	county_name	driver_gender	driver_age_raw	driver_age	driver_race	violation_raw	violation	search_
0	2005-01-02	01:55	NaN	M	1985.0	20.0	White	Speeding	Speeding	
1	2005-01-18	08:15	NaN	M	1965.0	40.0	White	Speeding	Speeding	
2	2005-01-23	23:15	NaN	M	1972.0	33.0	White	Speeding	Speeding	
3	2005-02-20	17:15	NaN	M	1986.0	19.0	White	Call for Service	Other	

Course Overview

Jupyter Notebooks

The diagram illustrates the components of a Jupyter Notebook. On the left, a vertical stack of six boxes labeled 'explanation', 'coding', 'output', 'explanation', 'coding', and 'output' has arrows pointing to specific sections of a Jupyter Notebook interface on the right.

explanation points to the notebook title: **PyCon 2018: Using pandas for Better (and Worse) Data Science**

coding points to the first code cell:

```
In [1]: import matplotlib.pyplot as plt
import pandas as pd
pd.__version__
```

output points to the output of the first cell:

```
Out[1]: '0.24.1'
```

explanation points to the dataset description: **Dataset: Stanford Open Policing Project ([video](#))**

coding points to the second code cell:

```
In [2]: # ri stands for Rhode Island
ri = pd.read_csv('police.csv')
```

output points to the third code cell:

```
In [3]: # what does each row represent?
ri.head()
```

output points to the output of the third cell, which is a table:

```
Out[3]:
```

	stop_date	stop_time	county_name	driver_gender	driver_age_raw	driver_age	driver_race	violation_raw	violation	search_
0	2005-01-02	01:55	NaN	M	1985.0	20.0	White	Speeding	Speeding	
1	2005-01-18	08:15	NaN	M	1965.0	40.0	White	Speeding	Speeding	
2	2005-01-23	23:15	NaN	M	1972.0	33.0	White	Speeding	Speeding	
3	2005-02-20	17:15	NaN	M	1986.0	19.0	White	Call for Service	Other	

Course Overview

Google Colab

<https://colab.research.google.com/>

You'll need a Google account.

Select “New Notebook” on the bottom right of the form.

Do your first “Hello World!”



Course Overview

Local Installation?

Please come to office hours
(tinyurl.com/4t39wwfw).

Local installation of Python
and Jupyter.

Any operating system.
Use your CPU.



Next Tasks

Relax

Any issues? Please come and talk to me.

CHALLENGE ACCEPTED

Sakai is up!

Please visit it as soon as possible.

Important announcements will be made there.

Start filling out your *Today-I-missed* Statement

Please visit <https://sakai.luc.edu/x/Dv5DsU>.

