Reproducibility Crisis

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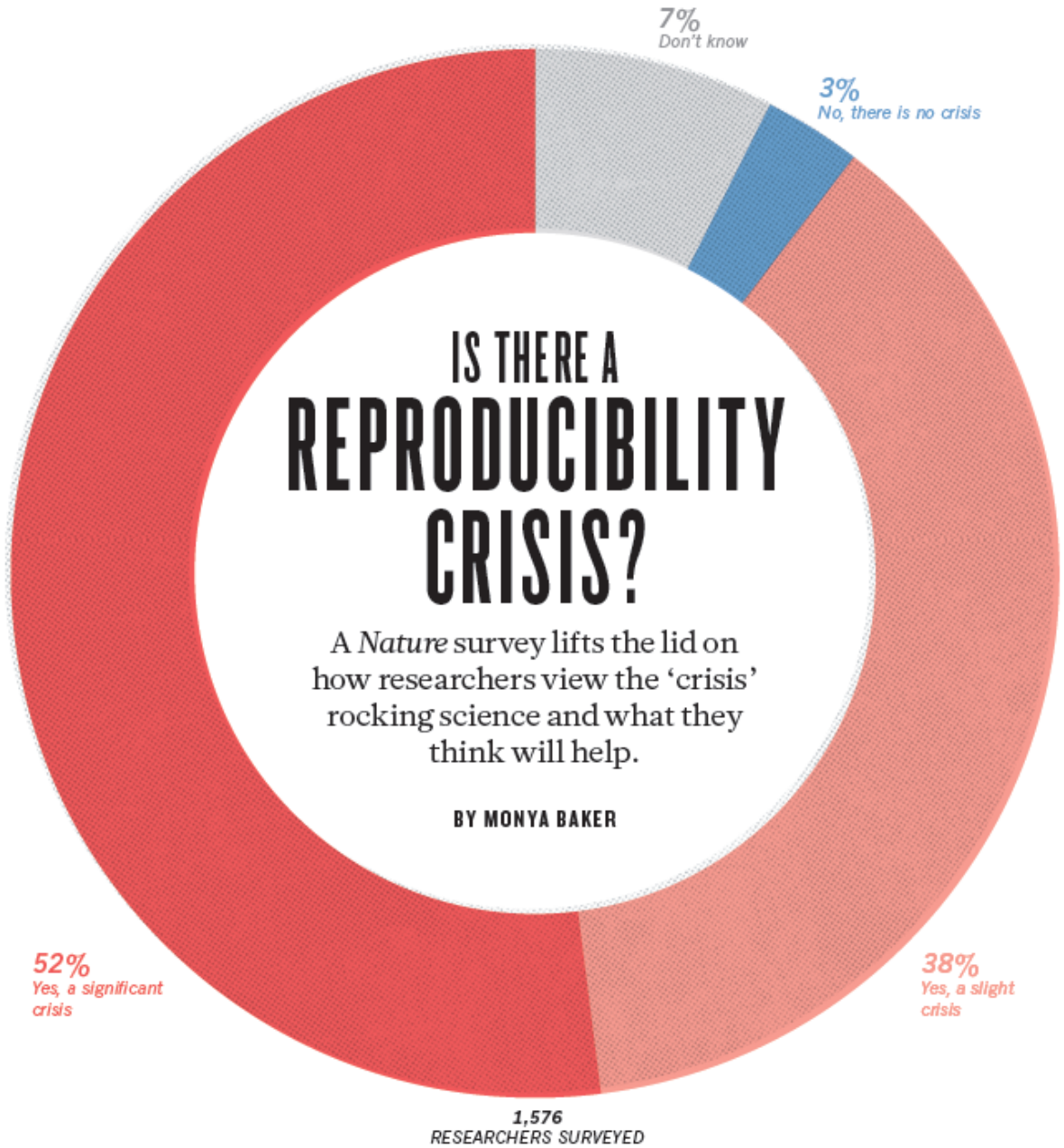
IS THERE A REPRODUCIBILITY CRISIS?



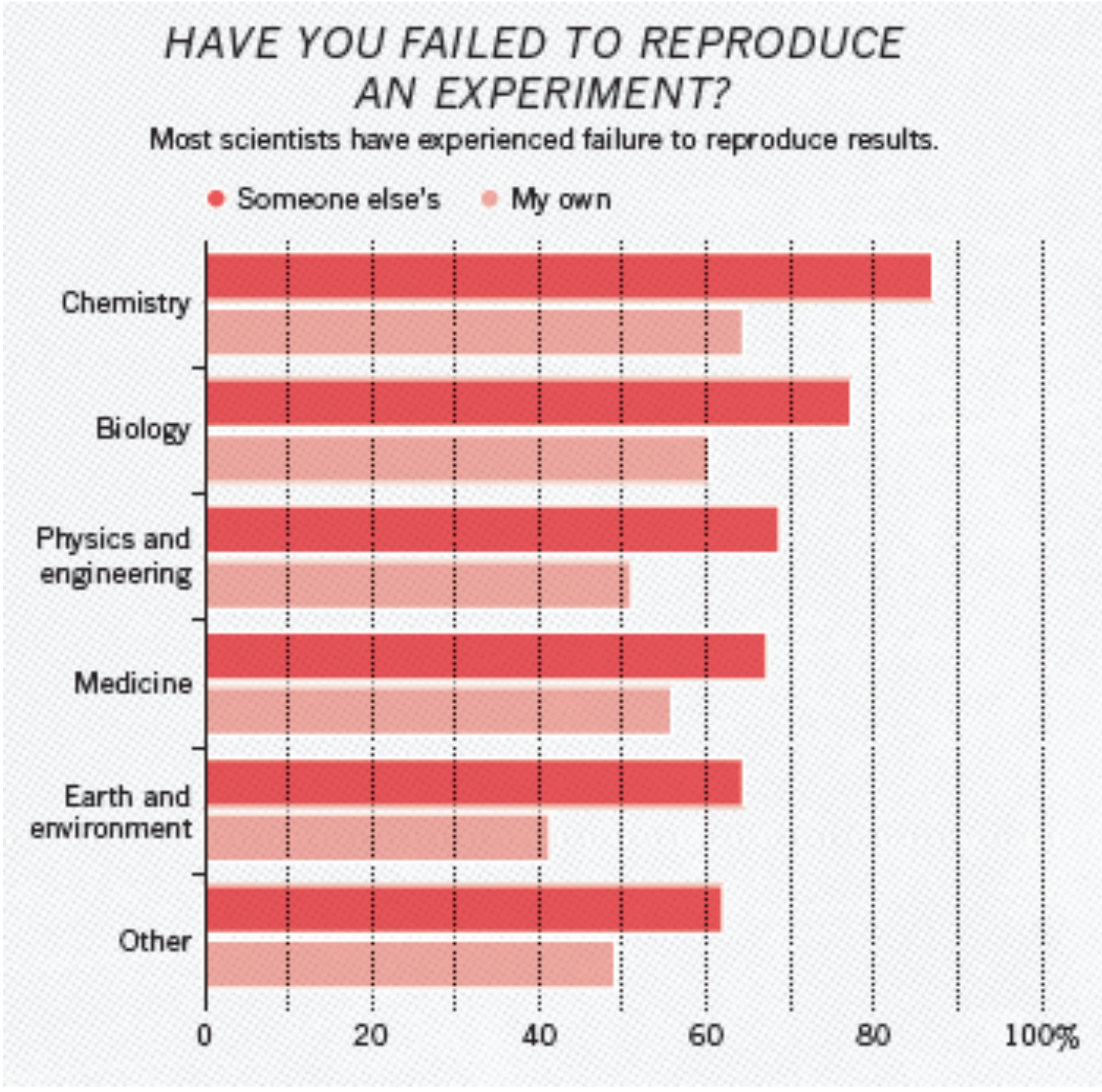
IS THERE A REPRODUCIBILITY CRISIS?

A *Nature* survey lifts the lid on how researchers view the 'crisis' rocking science and what they think will help.

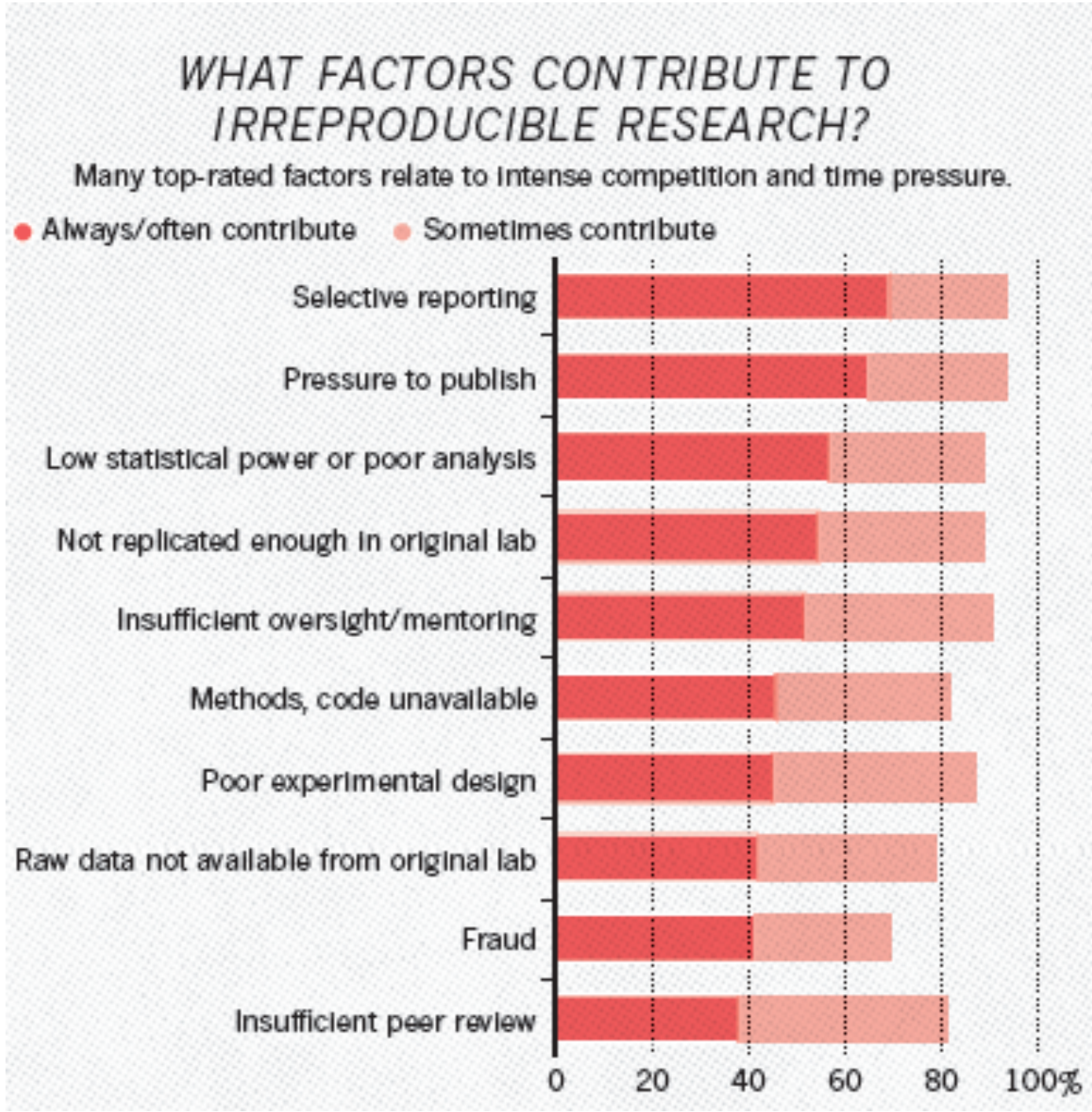
BY MONYA BAKER

HAVE YOU FAILED TO REPRODUCE AN EXPERIMENT?

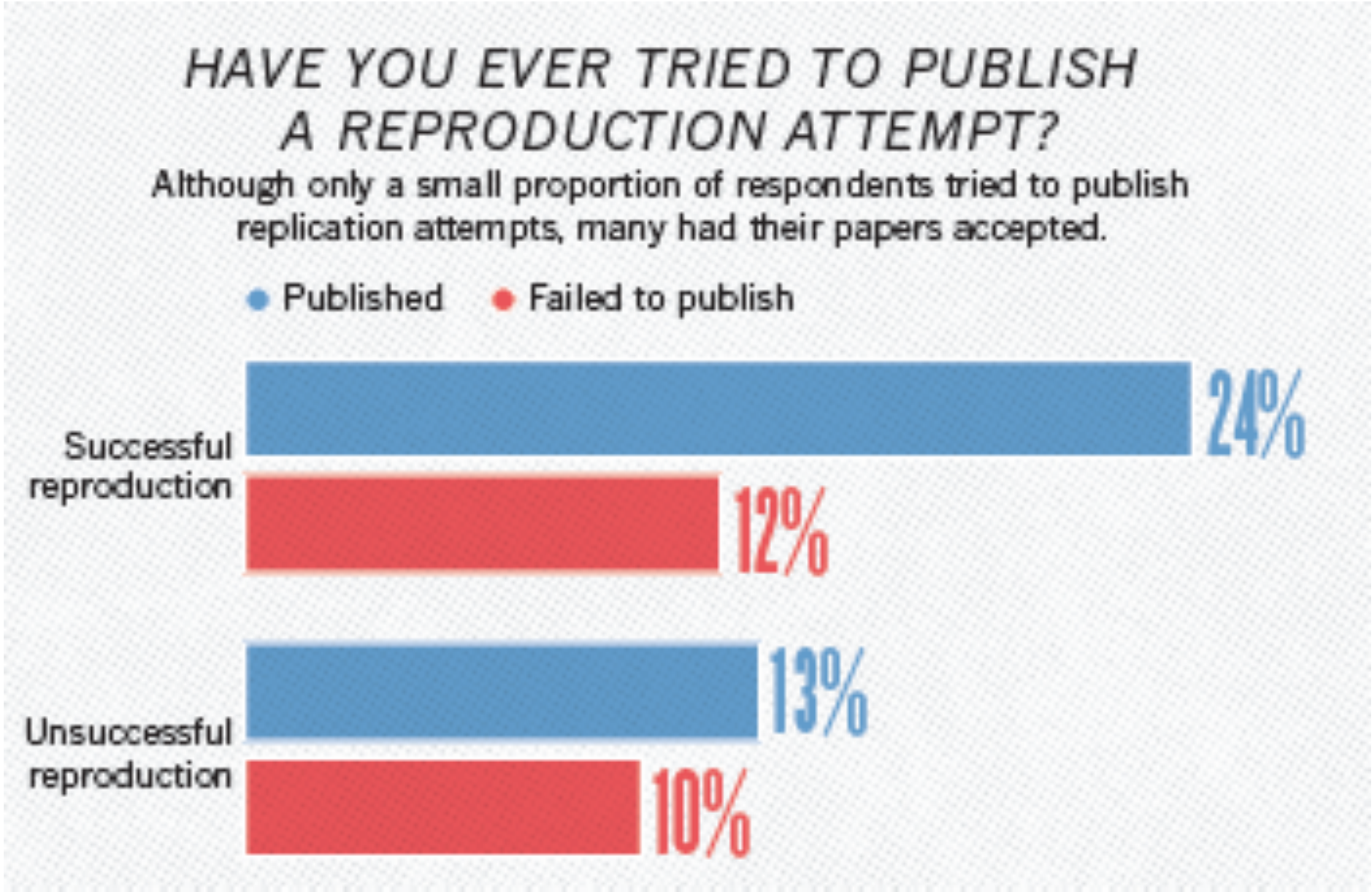
- Some one else’s
- Your own


HAVE YOU FAILED TO REPRODUCE AN EXPERIMENT?
Most scientists have experienced failure to reproduce results.
Someone else's
My own
Chemistry
Biology
Physics and engineering
Medicine
Earth and environment
Other
0
20
40
60
80
100%

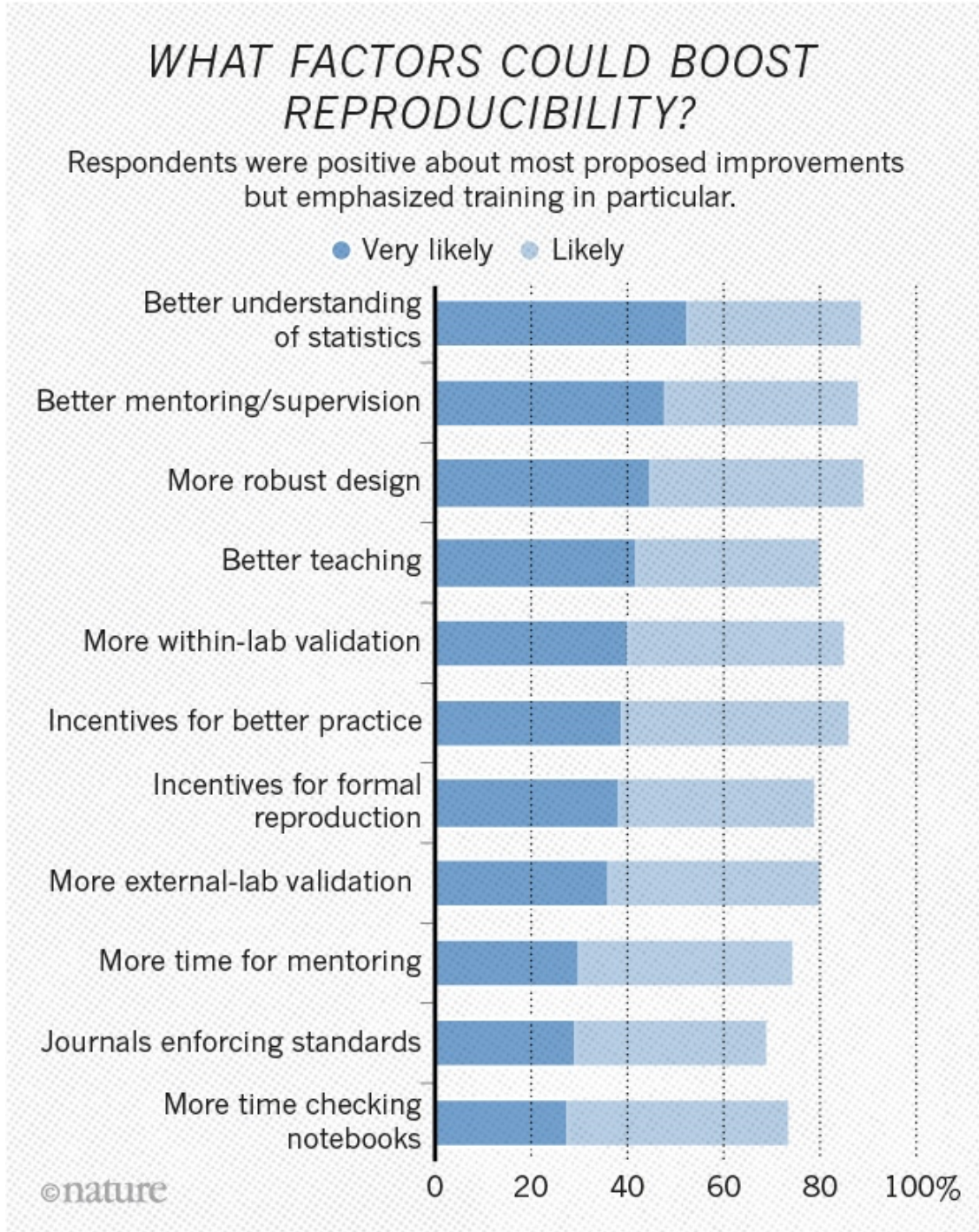
WHAT FACTORS CONTRIBUTE TO IRREPRODUCIBLE RESEARCH?


WHAT FACTORS CONTRIBUTE TO IRREPRODUCIBLE RESEARCH?
Many top-rated factors relate to intense competition and time pressure.
Always/often contribute
Sometimes contribute
Selective reporting
Pressure to publish
Low statistical power or poor analysis
Not replicated enough in original lab
Insufficient oversight/mentoring
Methods, code unavailable
Poor experimental design
Raw data not available from original lab
Fraud
Insufficient peer review
0
20
40
60
80
100%

HAVE YOU EVER TRIED TO PUBLISH A REPRODUCTION ATTEMPT?


HAVE YOU EVER TRIED TO PUBLISH A REPRODUCTION ATTEMPT?
Although only a small proportion of respondents tried to publish replication attempts, many had their papers accepted.
Published
Failed to publish
Successful reproduction
24%
12%
Unsuccessful reproduction
13%
10%

WHAT FACTORS COULD BOOST REPRODUCIBILITY?


WHAT FACTORS COULD BOOST REPRODUCIBILITY?
Respondents were positive about most proposed improvements but emphasized training in particular.
Very likely
Likely
Better understanding of statistics
Better mentoring/supervision
More robust design
Better teaching
More within-lab validation
Incentives for better practice
Incentives for formal reproduction
More external-lab validation
More time for mentoring
Journals enforcing standards
More time checking notebooks
0
20
40
60
80
100%
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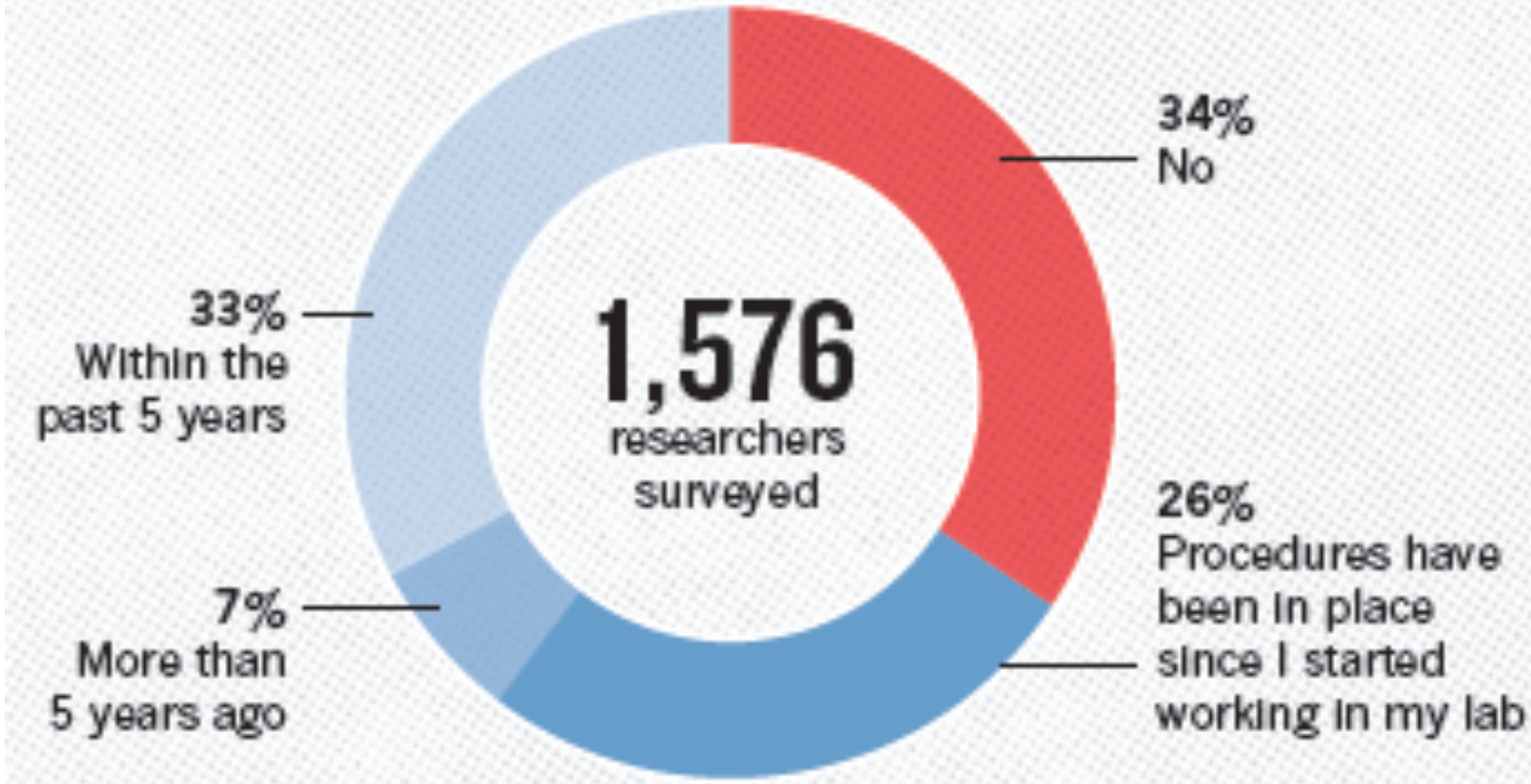
HAVE YOU ESTABLISHED PROCEDURES FOR REPRODUCIBILITY?

HAVE YOU ESTABLISHED PROCEDURES FOR REPRODUCIBILITY?

Among the most popular strategies was having different lab members redo experiments.



The NIH initiative

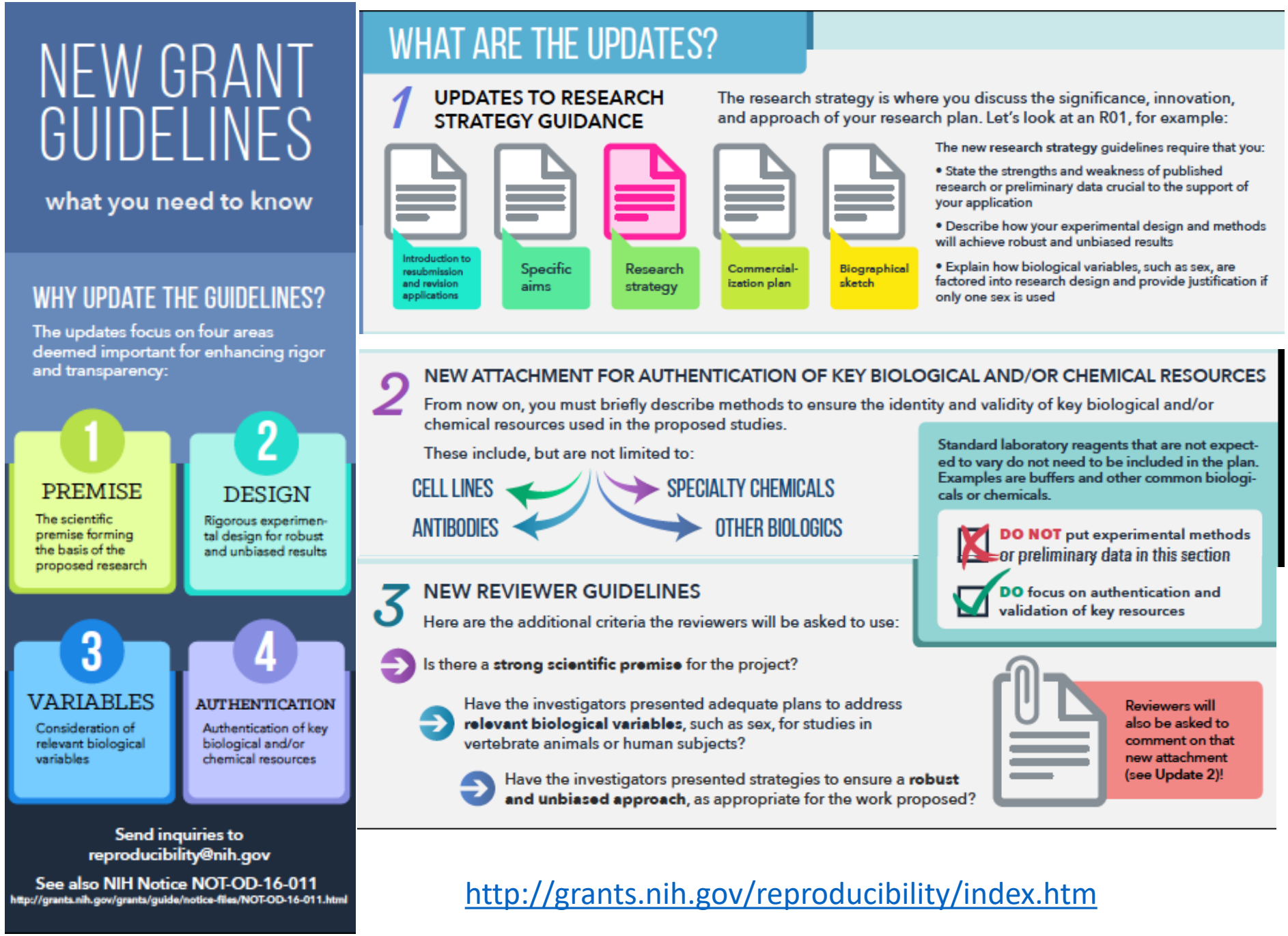
- Students may not be receiving adequate training early in graduate school in experimental design and other skills related to conducting rigorous and reproducible research’

Training grants

- Training grants, Career Development and Individual fellowships will require formal instructions in
  - Rigorous experimental design
  - Transparency to enhance reproducibility

- Boot camp supported under ‘Administrative supplements to NIGMS Predoctoral Training Grants (PA-15-136)’

- PSU commitment to conduct boot camp for next five years



http://grants.nih.gov/reproducibility/index.htm

Sources of Lack of Reproducibility

Sources of Lack of Reproducibility

- Fabrication, Falsification, plagiarism, misconduct
- Inadequate measures for data quality and reproducibility
- Biased reporting of results
- Inappropriate analysis
- Incomplete description of methods

Historic cases of Scientific Misconduct

- Charles Darwin
  - Origin of Pose: Saying ‘Cheese’ for Darwin NY Times, April 25, 1998 http://www.nytimes.com/1998/04/25/books/origin-of-the-pose-saying-cheese-for-darwin.html
- Louis Pasteur
  - Pasteur and culture wars, an exchange, The New York Review of Books, Dec 21, 1995; http://www.nature.com.ezaccess.libraries.psu.edu/search/adv_search?sp-q-1=nature,news
- Gregory Mendel
  - Beyond the Mendel-Fisher Controversy, Science, 350, 159, 2015, http://www.sciencemag.org.ezaccess.libraries.psu.edu/content/350/6257/159.full?sid=db800037-6596-432a-a00b-50bbe9d59686

Fraud/Misconduct

- Mark Spector
  - https://www.the-scientist.com/?articles.view/articleNo/26694/title/My-Favorite-Fraud/
- Where are they now
  - http://www.nature.com.ezaccess.libraries.psu.edu/articles/445244a
- Scientific Misconduct, Ann. Rev. Psychology, 67, 693, 2016
  - http://www.annualreviews.org.ezaccess.libraries.psu.edu/doi/full/10.1146/annurev-psych-122414-033437

Fabrications

- William Summerlin (1974) Memorial Sloan-Kettering Research Institute
  - Transplant research: expected change in coat color; drew patches on mice with a black marker pen

How common are fraud, fabrication and falsification?

- 1-2% in anonymous survey admit falsification of data
- Much higher percentage admit dropping a data point or not publishing contradictory results
- Questionable research practices are much higher

Misrepresentation and Distortions

- More common than fraud, fabrication, falsification, plagiarism and misconduct of research

Concept of spin

“a form of propaganda, achieved by providing a biased interpretation of an event or campaigning to persuade public opinion in favor of or against some organization or public figure”

Boutron and Ravoud, PNAS, 115, 2613, 2018

Spin

- A specific reporting that fails to faithfully reflect the nature and range of findings and that could affect the impression that the results produce in readers, a way to distort science reporting *without actually lying*
- Conscious, unconscious and unintentional
- Legitimate in some contexts
- In others, may create inaccurate impression of the study results

Spin

- The consequence of a lack of understanding of methodologic principles
- A parroting of common practices
- A form of unconscious behavior
- An actual willingness to mislead the reader
- Favors the author’s vested interest (financial, intellectual, academic, and so forth)

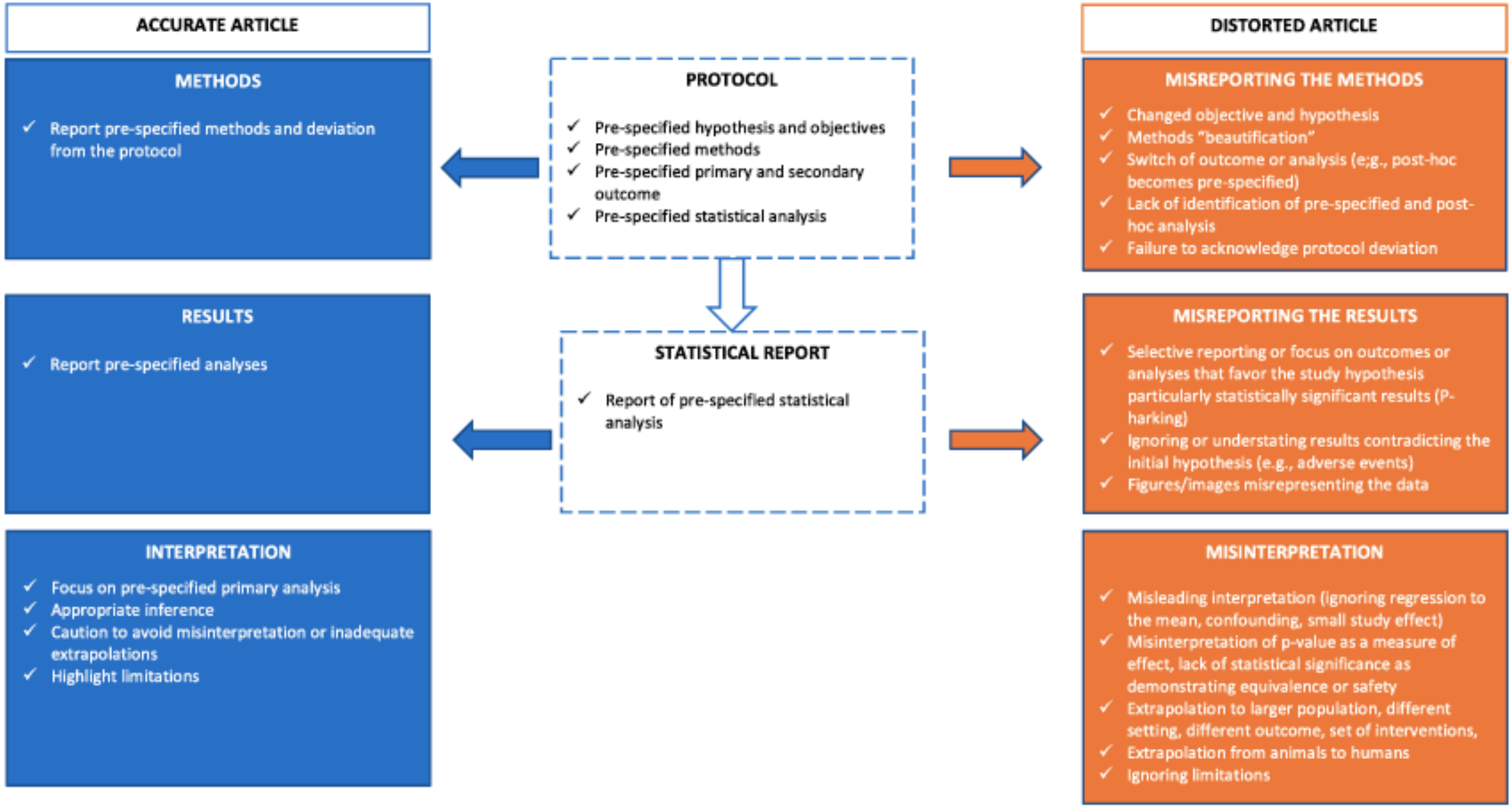
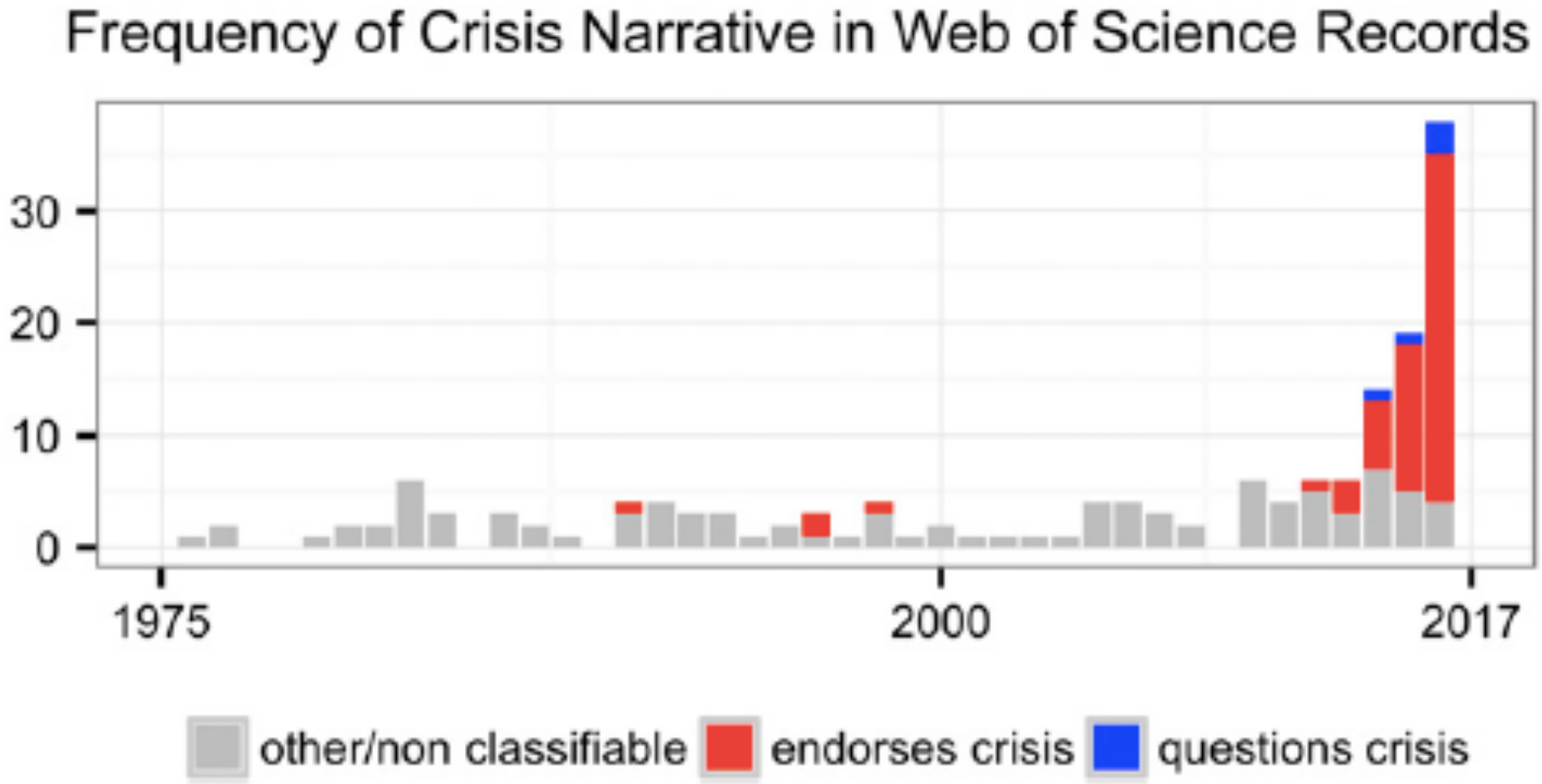


Fig. 1. Practices of spin in published reports.

Is science really facing a reproducibility crisis, and do we need it to?

Daniele Fanelli[a,1]



PNAS 115, 2628, 2018

- Published studies are getting longer, more complex and *richer in data*
- *Negative results* are increasingly getting embedded in longer publications
- *Globalization* of research is contributing to the rise in scientific misconduct in publication
- Rising power of information and communication technologies are transforming *scientific practices*

Reproducibility failures are essential to scientific inquiry

A. David Redish[a,1], Erich Kummerfeld[b], Rebecca Lea Morris[c], and Alan C. Love[d]

PNAS, 115, 5042, 2018

Scientific Progress

- Observation
- Theory
- Replication
- Failure
- Re-integration

- *There is a widespread misunderstanding about the role of reproducibility in science*

Reproducibility and Scientific Progress

- Karry Mullis
  - Polymerase Chain Reaction
- Beatrice Mintz
  - Chimera of mouse embryonic cells +teratoma cells
  - Pluripotent stem cells
- Carl Illmensee
  - Cloning experiment
  - Imprinting: Surani, Solter
  - Vindicated?
- Rudolf Jaenisch
  - Reproduced important results of mouse cloning, induced pluripotent stem cells (iPS)

Fig. 1. Discussions about a "reproducibility crisis" often ignore what takes place when reproducibility fails: the integration of conflicting observations and ideas into a coherent theory. Image courtesy of Dave Cutler (artist).

Reproducibility Failures

- Time necessary to reconcile conflicting results
- Attention to the process of reconciling conflicting results
- Synthesis of diverse perspectives to be encouraged
- Theoretical integration leads to reliable results

Scientific Progress

- Scientific discovery is an observation in under a given set of conditions
- When unable to replicate, one focuses on determining hidden variables
- Over a given time diverse outcomes including reproducibility failures get incorporated into a broader account

Failure to Generalize

In many of these cases, what have been called "failures to replicate" are actually failures to generalize across what researchers hoped were inconsequential changes in background assumptions or experimental conditions.

Scientific progress despite irreproducibility: A seeming paradox

It appears paradoxical that science is producing outstanding new results and theories at a rapid rate at the same time that researchers are identifying serious problems in the practice of science that cause many reports to be irreproducible and invalid.

PNAS, 115, 2632, 2018