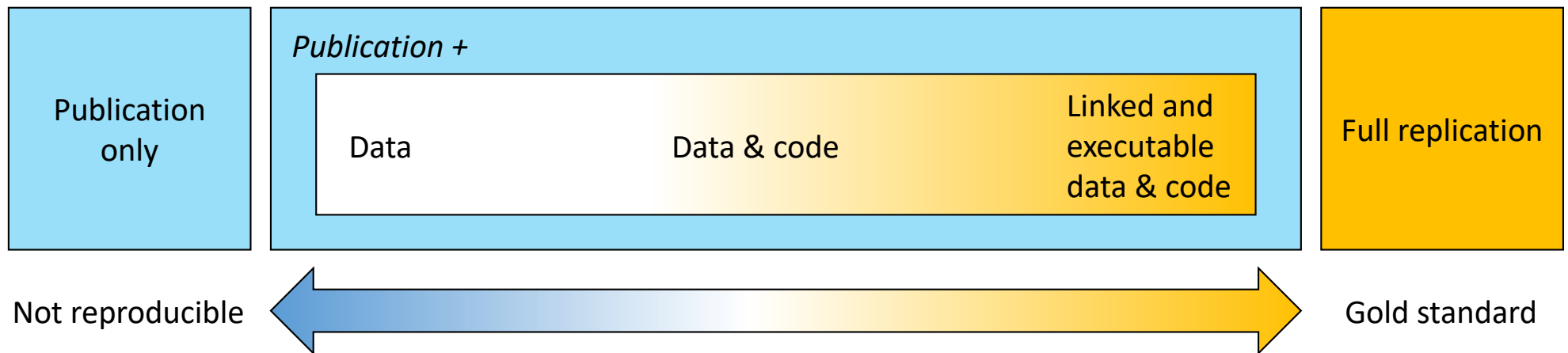
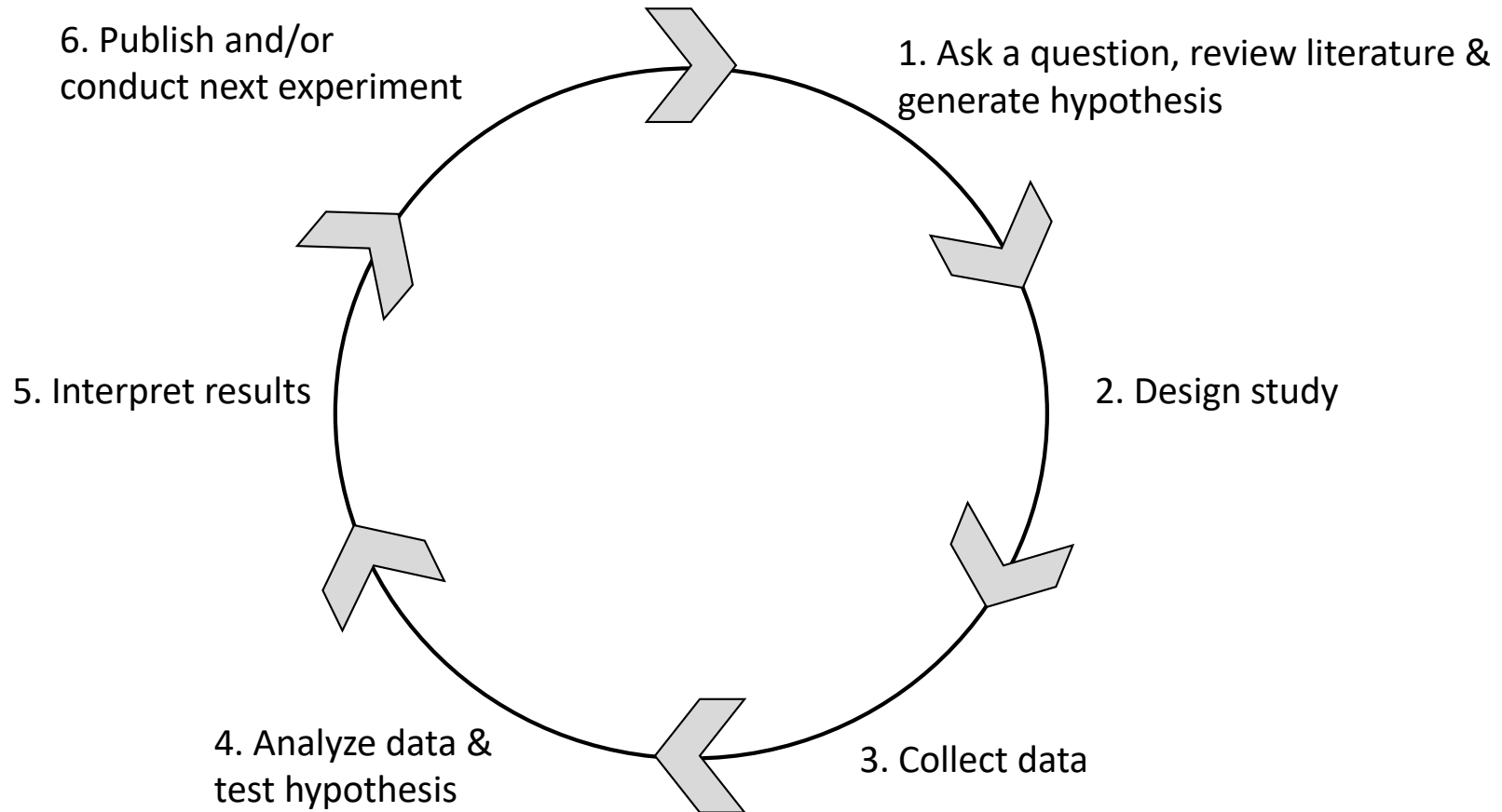


EEB 603 – A road map to implement reproducible science in Ecology & Evolution



THE SCIENTIFIC PROCESS



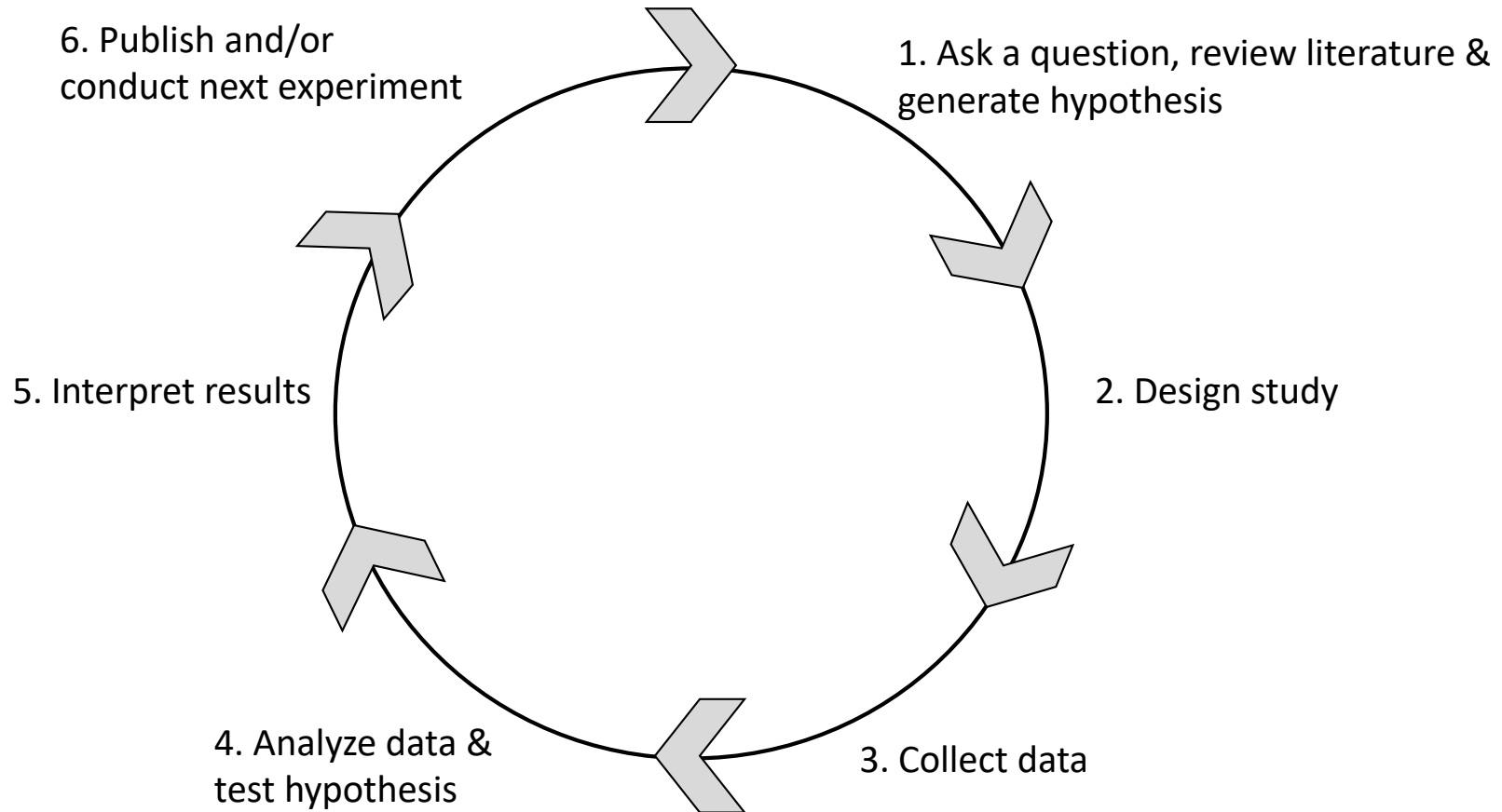
WHAT IS A HYPOTHESIS?

- A **hypothesis** is a tentative, **testable answer to a scientific question**.
- Use question to perform a literature review to establish baseline information on the topic.
- Use evidence from literature review to articulate a hypothesis, which tentatively answers your scientific question.
- The hypothesis must be testable since the next step will be to conduct an experiment to determine the validity of the hypothesis.

WHAT IS A HYPOTHESIS?

- A hypothesis leads to one or more predictions that can be tested by experimenting.
- Predictions often take the shape of "If ... then ... " statements, but do not have to.
- Predictions should include both an independent variable (the factor you change in an experiment) and a dependent variable (the factor you observe or measure in an experiment).
- A single hypothesis can lead to multiple predictions.

THE SCIENTIFIC PROCESS

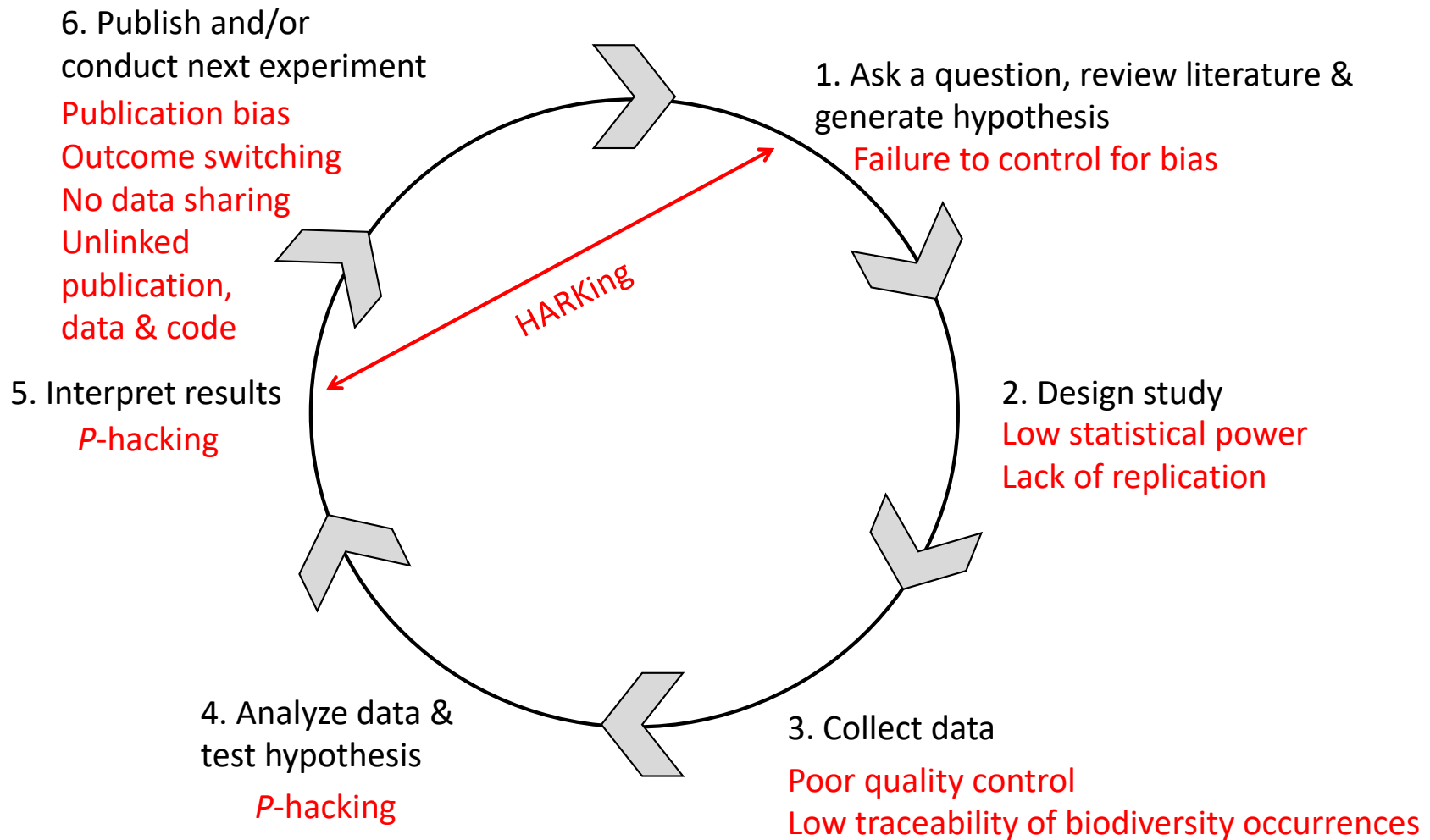


THREATS TO THE SCIENTIFIC PROCESS

“The first principle is that you must not fool yourself – and you are the easiest person to fool.” Richard Feynman

Richard Feynman (1918-1988) was one of the great scientists and physicists of our time. He won a Nobel Prize for his work in developing an understanding of quantum mechanics.

THREATS TO THE SCIENTIFIC PROCESS



DEFINITIONS OF THE THREATS

- **HARKing:** HARKing (hypothesizing after the results are known) is defined as presenting a *post hoc* hypothesis (i.e., one based on or informed by one's results) in one's research report as if it were, in fact, an *a priori* hypothesis.

DEFINITIONS OF THE THREATS

- ***P*-hacking**: also known as “Data dredging” is the misuse of data analysis to find patterns in data that can be presented as statistically significant when in fact there is no real underlying effect.
- ***P*-hacking** is done by **performing many statistical tests on the data and only paying attention to those that come back with significant results**, instead of stating a single hypothesis about an underlying effect before the analysis and then conducting a single test for it.

DEFINITIONS OF THE THREATS

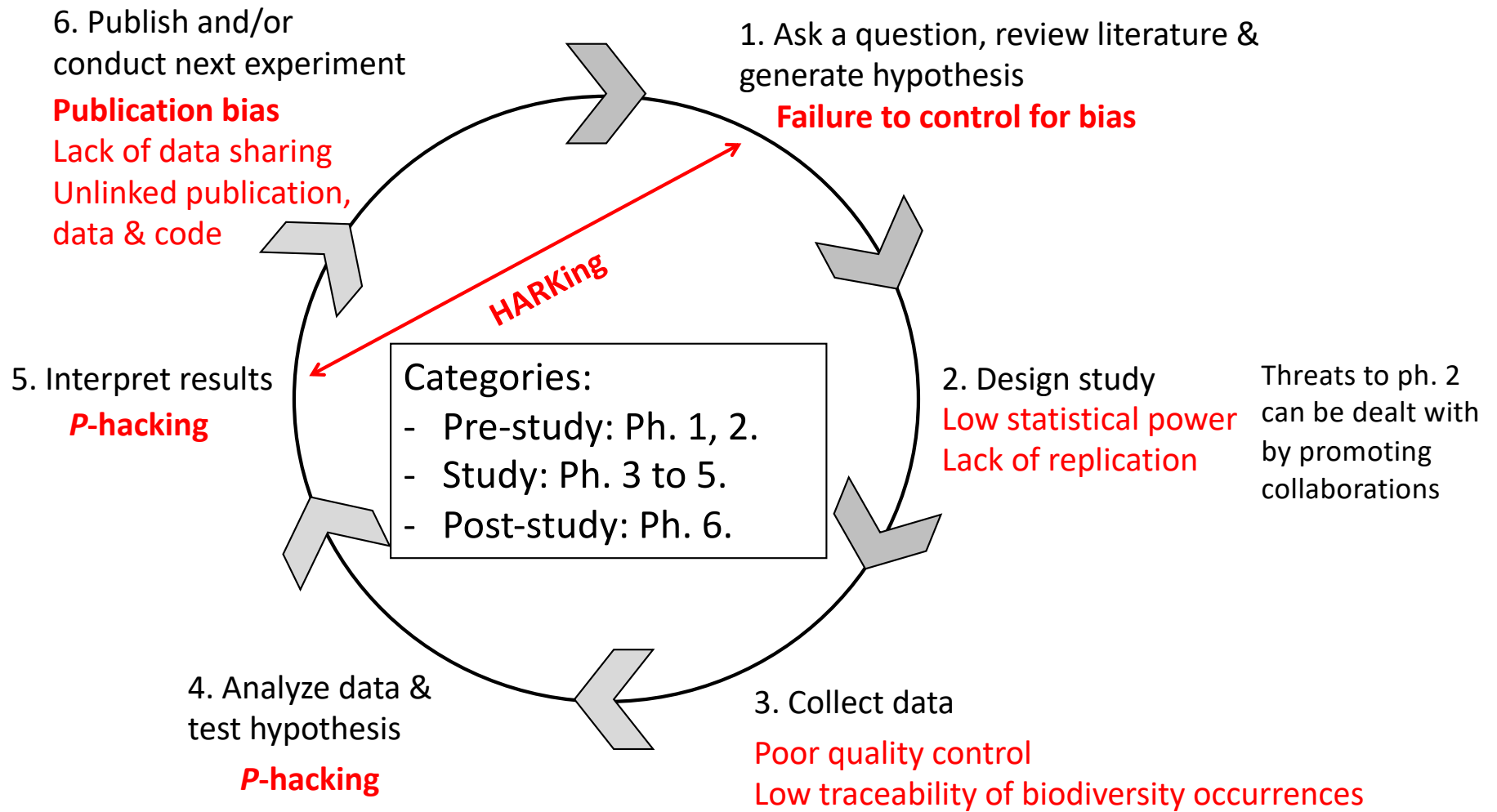
- **Publication bias:** also known as the file drawer problem, refers to the fact that many more studies are conducted than published. **Studies that obtain positive and novel results are more likely to be published than studies that obtain negative results or report replications of prior results.**
- The consequence that the published literature indicates stronger evidence for findings than exists in reality.

DEFINITIONS OF THE THREATS

- **Outcome switching:** refers to the possibility of **changing the outcomes of interest in the study depending on the observed results.**
- For instance, a researcher may include ten variables that could be considered outcomes of the research, and — once the results are known — intentionally or unintentionally **select the subset of outcomes that show statistically significant results as the outcomes of interest.**
- The consequence of this bias is an increase in the likelihood that reported results are spurious by leveraging chance, while negative evidence gets ignored.

How can we fix these threats?

By splitting the scientific process into 3 categories and writing a study pre-registration (or a research proposal as requested by the EEB program)



PROMOTING STUDY PRE-REGISTRATION

- **Progress in science relies in part on generating hypotheses with existing observations and testing hypotheses with new observations.** This distinction between postdiction (explanation after the facts) and prediction is appreciated conceptually, but it is not respected in practice.
- **An effective solution is to define the research questions and analysis plan before observing the research outcomes—a process called pre-registration.**

PROMOTING STUDY PRE-REGISTRATION

- In its simplest form study pre-registration may simply comprise the registration of the basic study design, but it can also include a detailed pre-specification of the study procedures, outcomes and statistical analysis plan.
- [Center for Open Science](#)



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What is Preregistration?

When you preregister your research, you're simply specifying to your plan in advance, before you gather data. Preregistration separates *hypothesis-generating* (exploratory) from *hypothesis-testing* (confirmatory) research. Both are important. But the same data cannot be used to generate and test a hypothesis, which can happen unintentionally and reduce the credibility of your results. Addressing this problem through planning improves the quality and transparency of your research, helping others who may wish to build on it.

For additional insight and context, you can read [The Preregistration Revolution](#).

Pre-registration will improve discoverability of research, but discoverability does not guarantee usability (and transparency)

PROMOTING USABILITY WITH THE TOP GUIDELINES

- **TOP guidelines offer standards as a basis for journals and funders to incentivize or require greater transparency in planning and reporting of research.**

The screenshot shows the OSFHOME website interface. The browser address bar displays 'osf.io/9f6gx/'. The OSFHOME logo is in the top left, and navigation links for Search, Support, Donate, Sign Up, and Sign In are in the top right. The main heading is 'Transparency and Openness Promotion (TOP) Guidelines'. Below the heading, there is a list of contributors and affiliated institutions. The description states that the TOP Guidelines were developed in November 2014 to address the need for greater transparency in scientific communication. The page also features a Wiki section with a snippet of text about the guidelines' purpose and a Components section listing related resources like 'Tools for Transparency in Ecology and Evolution (TTEE)' and 'TOP Resources - Evidence and Practices'.

OSFHOME

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Transparency and Openness Promotio... Files Wiki Analytics Registrations

Public P 3

Transparency and Openness Promotion (TOP) Guidelines

Contributors: Brian A. Nosek, George Alter, George Christopher Banks, Denny Borsboom, Sara Bowman, Steven Breckler, Stuart Buck, Chris Chambers, Gilbert Chin, Garret Christensen, Monica Contestabile, Allan Dafoe, Eric Eich, Jeremy Freese, Rachel Glennerster, Daniel Goroff, Don Green, Brad Hesse, Macartan Humphreys, John Ishiyama, Dean Karlan, Alan Kraut, Arthur Lupia, Patricia ("Patty") L. Mabry, Temina Madon, neil malhotra, Evan Mayo-Wilson, Marcia McNutt, Edward Miguel, Elizabeth Levy Paluck, Uri Simonsohn, Courtney K. Soderberg, Bobbie Spellman, James Turitto, Gary VandenBos, Simine Vazire, Eric-Jan Wagenmakers, Rick K. Wilson, Tal Yarkoni, Victoria Stodden,

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Date created: 2014-08-12 11:22 AM | Last Updated: 2020-09-08 01:33 AM

Category: Project

Description: The Transparency and Openness Promotion (TOP) Committee met in November 2014 to address one important element of the incentive systems - journals' procedures and policies for publication. The outcome of the effort is the TOP Guidelines. There are eight standards in the TOP guidelines; each move scientific communication toward greater openness. These standards are modular, facilitating adoption in whole or in part. However, they also complement each other, in that commitment to one standard may facilitate adoption of others. Moreover, the guidelines are sensitive to barriers to openness by articulating, for example, a process for exceptions to sharing because of ethical issues, intellectual property concerns, or availability of necessary resources.

License: CC 1.0 Universal

Has supplemental materials for Transparency and Openness Promotion (TOP) Guidelines on OSF Preprints

Wiki

Reproducibility of research can be improved by increasing transparency of the research process and products. The TOP Guidelines provide a template to enhance transparency in the science that journals publish. With minor adaptation of the text, funders can adopt these guidelines for research that they fund. The guidelines are the output of a meeting held in November 2014, organized by the Berkeley...

Read More

Citation

Components

Tools for Transparency in Ecology and Evolution (TTEE)
Parker, Bowman, Nakagawa & 4 more
This site offers tools that can be adopted by institutions to help promote transparency in ecology and evolution. At this point, these tools consist o...

TOP Resources - Evidence and Practices

PROMOTING USABILITY WITH THE TOP GUIDELINES

- **TOP guidelines include 8 modular standards, each with three levels of increasing stringency:**
 1. Citation standards (citation of data sets etc.)
 2. Data transparency (data archiving)
 3. Analytic methods (code) transparency (code archiving)
 4. Research materials transparency (materials archiving)
 5. Design and analysis transparency (reporting of details of methods and results)
 6. Pre-registration of studies (registering study prior to initiation)
 7. Pre-registration of analysis plans (registering analysis plan prior to study initiation)
 8. Replication (a study designed to replicate a previously published study)

TOP Guidelines summary table.

	Not Implemented	Level I	Level II	Level III
Citation Standards	Journal encourages citation of data, code, and materials, or says nothing.	Journal describes citation of data in guidelines to authors with clear rules and examples.	Article provides appropriate citation for data and materials used consistent with journal's author guidelines.	Article is not published until providing appropriate citation for data and materials following journal's author guidelines.
Data Transparency	Journal encourages data sharing, or says nothing.	Article states whether data are available, and, if so, where to access them.	Data must be posted to a trusted repository. Exceptions must be identified at article submission.	Data must be posted to a trusted repository, and reported analyses will be reproduced independently prior to publication.
Analytic Methods (Code) Transparency	Journal encourages code sharing, or says nothing.	Article states whether code is available, and, if so, where to access it.	Code must be posted to a trusted repository. Exceptions must be identified at article submission.	Code must be posted to a trusted repository, and reported analyses will be reproduced independently prior to publication.
Research Materials Transparency	Journal encourages materials sharing, or says nothing.	Article states whether materials are available, and, if so, where to access them.	Materials must be posted to a trusted repository. Exceptions must be identified at article submission.	Materials must be posted to a trusted repository, and reported analyses will be reproduced independently prior to publication.
Design and Analysis Transparency	Journal encourages design and analysis transparency, or says nothing.	Journal articulates design transparency standards.	Journal requires adherence to design transparency standards for review and publication.	Journal requires and enforces adherence to design transparency standards for review and publication.
Study Preregistration	Journal says nothing.	Article states whether preregistration of study exists, and, if so, where to access it.	Article states whether preregistration of study exists, and, if so, allows journal access during peer review for verification.	Journal requires preregistration of studies and provides link and badge in article to meeting requirements.
Analysis Plan Preregistration	Journal says nothing.	Article states whether preregistration of study exists, and, if so, where to access it.	Article states whether preregistration with analysis plan exists, and, if so, allows journal access during peer review for verification.	Journal requires preregistration of studies with analysis plans and provides link and badge in article to meeting requirements.
Replication	Journal discourages submission of replication studies, or says nothing.	Journal encourages submission of replication studies.	Journal encourages submission of replication studies and conducts results blind review.	Journal uses Registered Reports as a submission option for replication studies with peer review prior to observing the study outcomes.

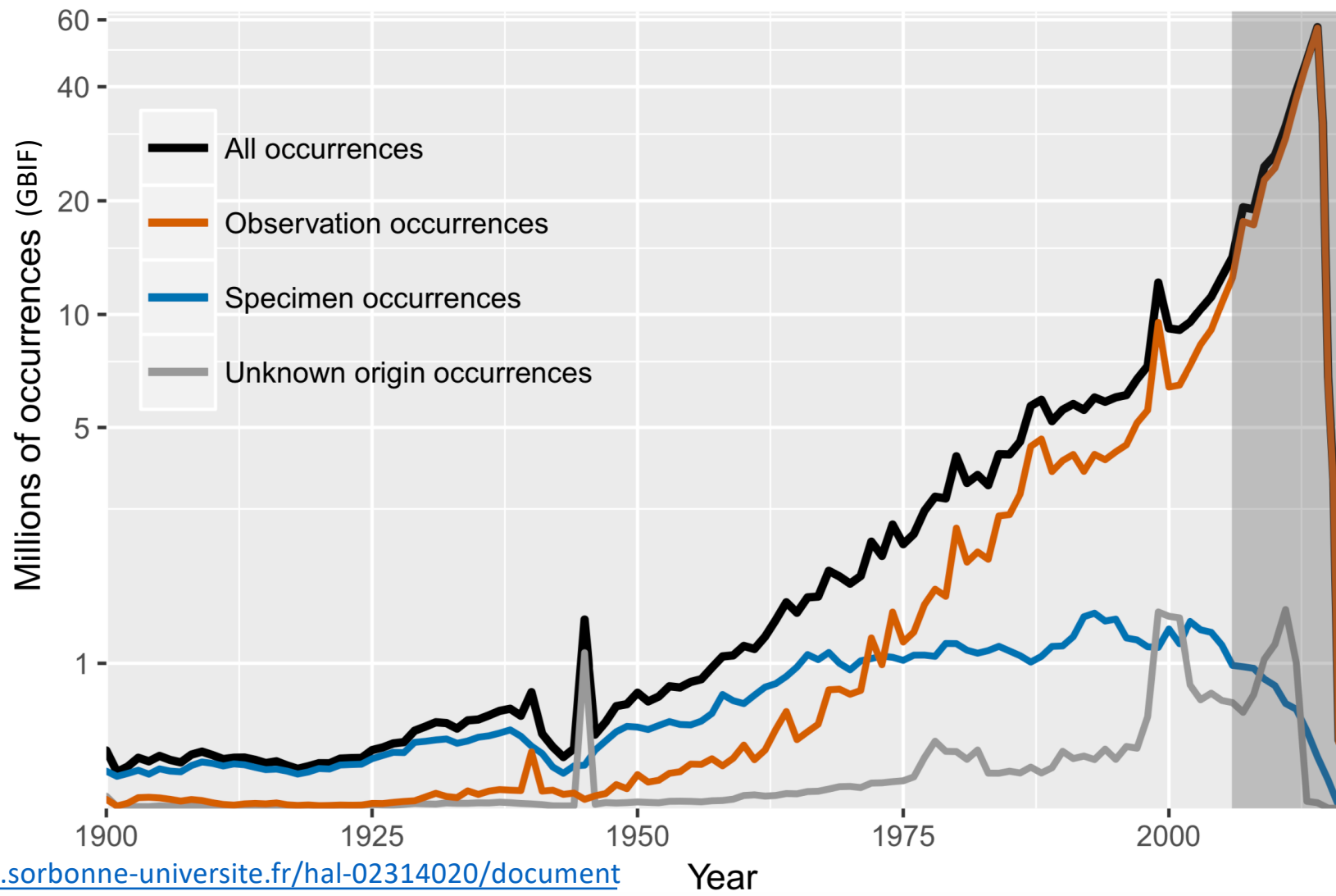
Adopting journals (>1k) select among the levels based on readiness to adopt milder to stronger transparency standards for authors and researchers.

PROMOTING EVIDENCE SUPPORTING BIODIVERSITY DATA

- **Primary biodiversity occurrence data are at the core of our research.** They are, however, no longer gathered as they used to be and the mass-production of observation-based (OB) occurrences is overthrowing the collection of specimen-based (SB) occurrences.

PROMOTING EVIDENCE SUPPORTING BIODIVERSITY DATA

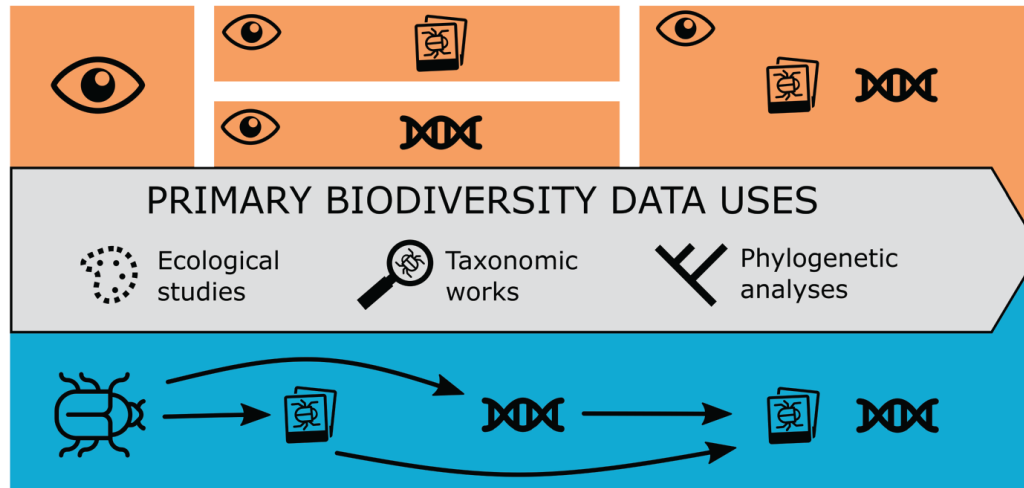
- Analyses conducted on 536 million occurrences from GBIF concluded that from 1970 to 2016 the proportion of occurrences marked as traceable to tangible material (SB occurrences) fell from 68% to 18%.
- This alarming trend (i.e. the low traceability of occurrences and therefore the low confidence of species identifications) threatens the reproducibility of biodiversity research.







<https://hal.sorbonne-universite.fr/hal-02314020/document>

PROMOTING EVIDENCE SUPPORTING BIODIVERSITY DATA

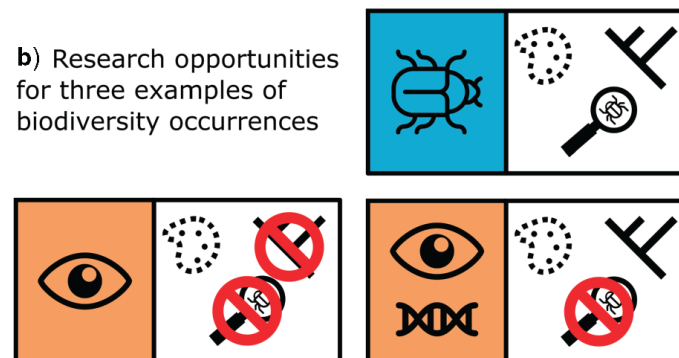
a) The different natures and uses of biodiversity occurrences



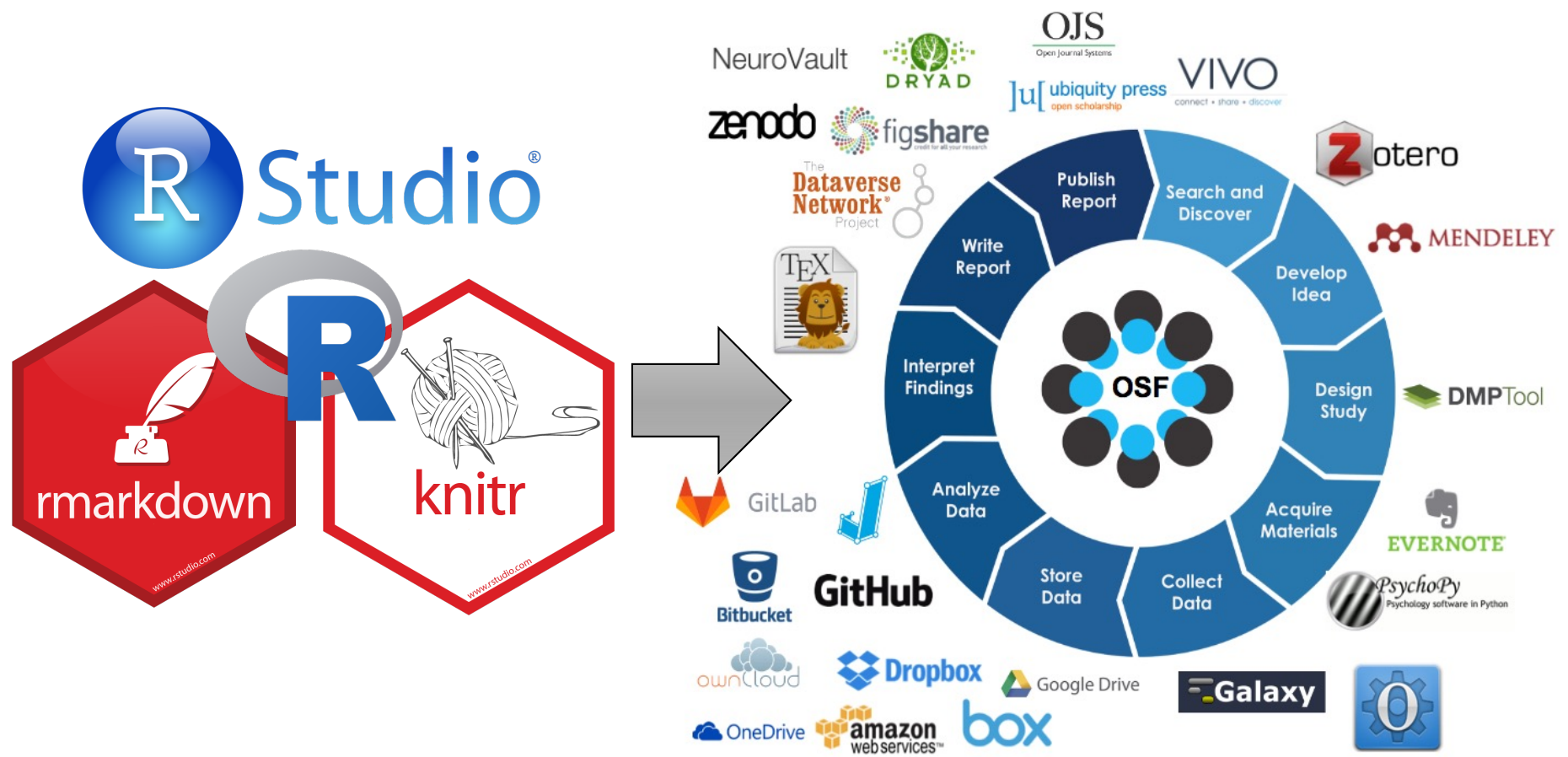
Legends

-  Observation
-  Specimen
-  Multimedia files
-  DNA sequences

b) Research opportunities for three examples of biodiversity occurrences



LINKING PUBLICATION, DATA, CODE & ANALYSES



IMPROVING RESEARCH DISSEMINATION & EVALUATION



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+ get feedback on your research before submitting paper and after publication
→ This speeds review process and expands it to larger scientific community

PROMOTE TRANSPARENCY & OPEN SCIENCE



Make research more transparent by sharing it for "free" (\$\$\$)



Funders need to support open science



European funders commit to science without paywalls by 2020

In a bold commitment to Open Access, 11 national research funding organizations, supported by the European Commission and the European Research Council (ERC), have announced their plan to make full and immediate Open Access to research publications a reality.

This coalition of European funders is implementing fundamental principles to mandate that from 1 January 2020, any scientist they fund publishes their research Open Access.