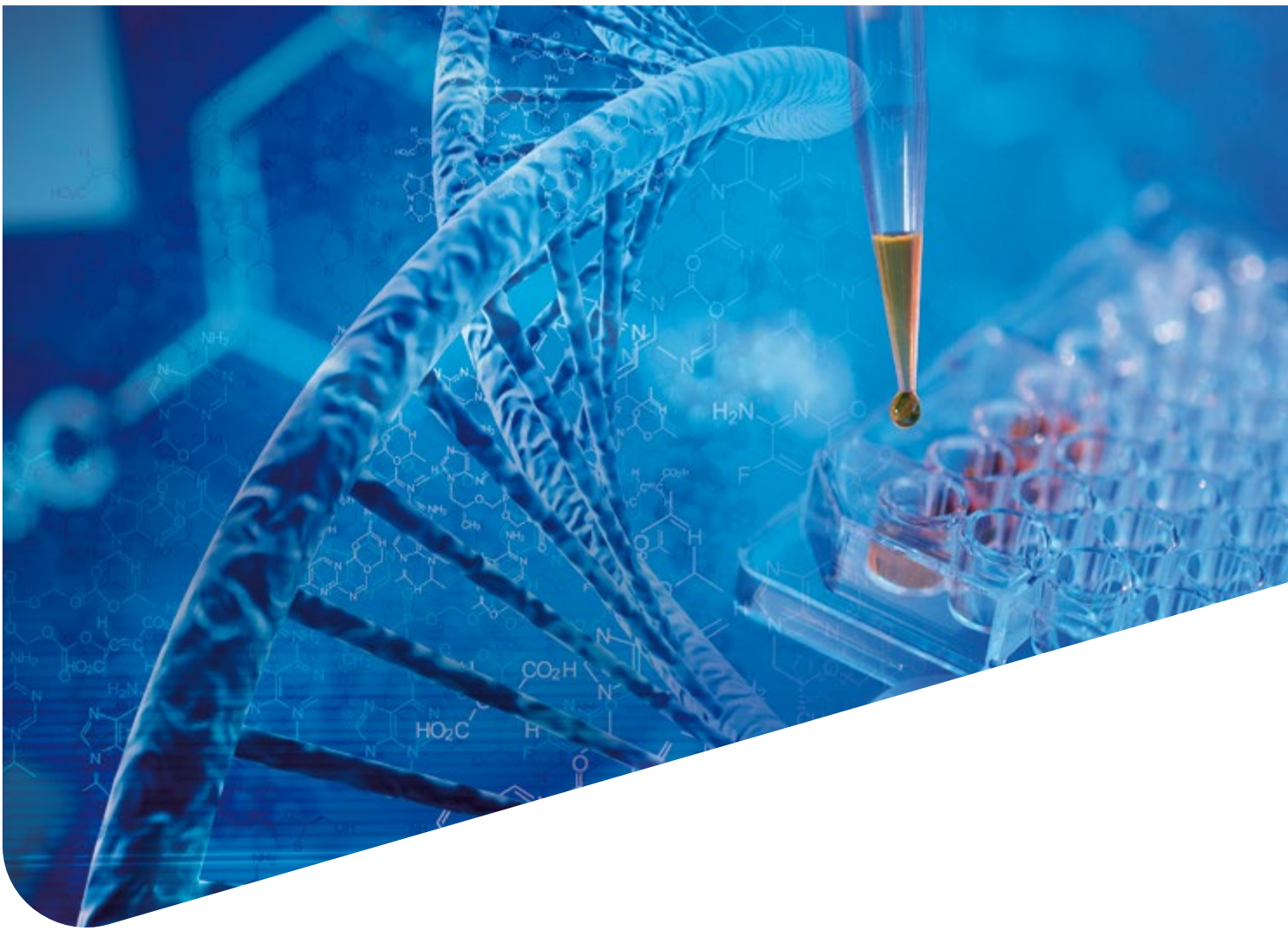

RESEARCH PROTOCOLS, KEY TO REPRODUCIBLE SCIENCE

ADVANCING DISCOVERY

Why do scientists need research protocols?

At the inception of every research paper is a question or problem that scientists are attempting to solve by performing various experiments that may support or refute their research hypothesis.

On the other hand, experimental protocols, often listed as part of the “Materials and Methods” section of scientific papers, are standardized procedures leading to pre-defined results.

Central for reproducibility, research protocols should provide the reader with all of the necessary information they need to replicate the experiments in their own lab with a consistent result.

Unfortunately, this isn’t always the case. These “Materials and Methods” sections summarize the methodology used in a concise way but often skip practical details, leaving scientists with questions such as:

- How long did they spin those samples for?
- Did they store the overnight suspension in a fridge or freezer?
- Exactly which ultra-high metal affinity column did they purchase?

If a researcher is unable to replicate the experiment correctly, it can lead to considerable waste of time and effort, sometimes having to restart an experiment after months of work. Resources in the lab can also be wasted, for example when costly reagents need to be repurchased.

Protocols in biology are divided into subject areas, including Biochemistry, Cell Biology, Molecular Biology, Neuroscience, Histology, Genomics and Plant Biology. Dry labs also have their own protocols.

"More than 70% of researchers have tried and failed to reproduce another scientist's experiments."
Is there a reproducibility crisis?
Monya Baker, Nature 533, 552-552 (2016)

Comparing a research paper and a research protocol side-by-side*

Research paper

Introduction
The introduction describes the research question the paper attempts to answer, along with the various hypothesis that will be explored for this purpose. It also reviews any relevant literature and assesses the significance and novelty of the study.

Results
Results and findings are reported while experiments data is compiled into charts or figures.

Discussion
In this section, the author(s) interpret the results and assess their similarity or difference with other published evidence to answer the knowledge gap within existing literature.

Method
This section deals with the experimental design of the study by listing the procedures performed.

Research protocol

Introduction
The introduction describes the protocol itself and outlines any theories and major procedures involved. It also states its objective, range of applications where it can be used, advantages and limitations.

Materials
Here are listed the compositions of all buffers, media, solutions and specialist equipment necessary for carrying out the procedure. It describes precisely the quantities used, sample replication, storage conditions, spinning and mixing, and details on how to operate various instruments and equipment.

Method
This section explains in detail the individual steps of the technique in a chronological and modular fashion in order to carry out the experiment in the researchers' own laboratory workflow. Timing information as well as critical steps and caution are also highlighted. Figures and tables are provided to support implementation.

Notes
Sometimes it is the little things that make an experiment work, for instance flicking a tube gently versus vortexing it.

These are exactly the type of details that can save researchers weeks and potentially months of time and effort in the successful implementation of a protocol.

* Illustrative example based on the paper CRISPR/Cas9 system targeting regulatory genes of HIV-1 inhibits viral replication in infected T-cell cultures, Youdiil Ophinni, Mari Inoue, Tomohiro Kotaki2 & Masanori Kameoka, Scientific Reports (2018) and protocol Beads-on-a-String on a Bead: Reconstitution and Analysis of Chromatin on a Solid Support, Raphael Sandaltzopoulos and Peter B. Becker, Chromatin Protocols, Methods in Molecular Biology, vol. 1288 (2015)

When are research protocols used?

Whenever a researcher is planning a new experiment, whether they are a junior researcher conducting an experiment in a new field of study or an experienced researcher looking to adapt their experiment to a new lab set up or sample/species, they will need to find a suitable protocol to help inform the study design. Often researchers will combine and adapt protocols to match their specific experimental context.

Protocols and methods also help researchers to keep up to date with the latest advances in research methodologies, including innovative technologies and cutting-edge techniques being developed by other researchers that may be applicable to their field.

Conclusion

Protocols should be thought of as stand-alone scientific articles that provide context and detail on the research methodology used in an experiment. The precise format and chronological reporting of the steps followed make it easier for researchers to reproduce an experiment.

A well-curated database of protocols can serve as the backbone of a high performing research laboratory. At Springer Nature, we offer a comprehensive and high-quality collection of research protocols with the SpringerProtocols series that has been supporting life science research since 1980.

- The largest and most established collection of protocols in biomedicine and life sciences with over 54,000 references
- Includes reviews and older versions of protocols, with content dating back nearly 40 years
- Quality, reviewed protocols enhancing reproducibility and promoting wider application of the method

"We ask the authors not to just present their protocol, but to give 'value added' by including their experiences with the method and any improvements they have made, hints and tips etc; this in particular is what the Notes section is for. Only by the method being used and tested in a range of labs do we find out if they are of any use at all. The methods we publish have proved their success and are trusted by the labs that use them so successfully."

John Walker, Editor-in-Chief, SpringerProtocols

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