Read A Paper
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PROLOGUE

The scientific method refers to the procedures used by scientists to understand the natural (observable) world. Although there is no set of accepted rules, science requires an empirical stance. That is, one based on evidence and subject to experimental test. Basically, nothing is sacred and everything is open to rational criticism. The process should be objective in the sense that experiments should be independent of the scientist doing them. That is, they must be replicated and nothing is concealed that is necessary to allow replication (full disclosure).

Here is my formulation of the critical elements of a scientific method.

1) Theories are connected to observations. That is, they organize and make observations understandable.

2) Theories are subject to experimental test. That is, they make predictions about observable quantities.

3) Predictions obey rational and logical rules, sometimes, but not always, having mathematical basis.

4) Everything is open. Results must be published in such a way that experiments and observations can be replicated.

However, this does not mean that there is no dogmatism. Accepted theories, models and hypotheses embody science. These are - hopefully - continually tested and rejected when they are not supported by empirical evidence. Theories are replaced when alternatives better explain observation. More often, perhaps almost always, theories are modified rather than completely replaced.

An example would be the "dogma" that DNA serves as a template for RNA messages that are translated in protein. If this ever was a dogma it has been modified in at least two ways. Reverse transcriptase allows ssRNA to be transcribed into dsDNA. More hypothetically, an early "RNA world" may have lacked entirely DNA and perhaps as well, protein.

The scientific method relies on a consensus about acceptable theories and models. These are continually refined by experiments that are based on them and designed to test them. For example, a consensus model of a proteins three-dimensional structure might be that its N-terminal domain has an alpha helix of 25 amino acids. Further work (perhaps using x-ray diffraction analysis) may show that in fact there are only 24 amino acids in its structure. This is a new model that better explains all available data.

But where can we find these consensus theories and models? Where are the empirical data on which they are based? And perhaps more importantly, where are the methods for deriving models from theories, predictions from models and the techniques for making acceptable experimental observations?

These things reside in the scientific literature. It contains the accepted ideology of science. But it is neither accepted nor interpreted in the same way by everyone. Rather, it is in a constant state of flux, subject to scientific criticism by rational analysis of empirical observations.

The fundamental unit of scientific literature is the "peer reviewed" (refereed) paper. In theory one or more impartial and anonymous experts in the field do this review. Defects of this process are well known, for example a specific paper is more likely to be accepted if it is published under the name of a leading scientist than an unknown one. Nevertheless, it is the cornerstone in screening research that will become part of a scientific consensus. Hopefully, worthwhile ideas and data will eventually find their way into the literature, even if not credited to their original discoverer.

UNDERSTANDING A RESEARCH PAPER

It should be clear from the prologue that evaluating research papers has at least two purposes. The first is a passive process, to increase your own understanding of the scientific paradigm, especially that directly related to your own areas of interest. The second is potentially active, to participate in the scientific process. This would involve critical evaluation of the paper's contributions and publication of your own research.

Distinguishing in this way understanding and criticism, we will concentrate on the former. Most papers consist of four sections: introduction, methods, results and conclusions. You will read the assigned paper ***and answer the four questions*** that are provided below in bold print. Needless to say, there is no "correct" answer to these questions. You will provide your own opinion on four separate pages in your lab book. After the class discussion, you will repeat this, giving a revised answer and evaluating your initial effort. Give yourself a grade based on your initial understanding.

Introduction

Q1 What Question(s) does the paper ask?

The introduction should set the background for the paper and defines its "scope". What specific questions are addressed? This includes a "framework" for these questions. What are the relevant theories and models? How are they applied? Does the paper present data required by a theory or model? Are hypotheses tested? Does the paper extend a model to a new system or to new conditions? Does the paper offer a new model or theory?

It is frequently the case that a reader does not adequately understand the theories on which a paper is based. If this is the case, admit it and describe what additional knowledge you think you need in order to fully understand the paper.

Methods

An important part of scientific papers is its methods section. Methods allow experiments to be repeated. Without replication, the validity of the results cannot be assessed. Statistical evaluation of results should be used to show that they are relevant and that they are unlikely to have been obtained with alternate models to those being tested.

What level of understanding should you aim for? It is rare that anyone, even the authors, understands completely all the experimental techniques used in a research paper. This is especially important with respect to the sources of data. For example, Plasmids used in cloning. Are sources for experimental material referenced? Could anyone obtain the data that has been analyzed? Modern scientific techniques are complex and often rely on equipment and "kits" supplied by manufacturers. Perhaps what can reasonably be asked is that we know the techniques sufficiently well to understand their scientific basis and whether they are appropriate to the problem.

Q2 Outline each experiment and experimental methods. Are these described sufficiently so that the experiment could be replicated? Do you understand the concepts of each method?

Results

In principle, results should be presented without interpretation. However, it is often necessary to guide the reader's understanding of complex results. The background of each experiment should be developed to show how it is relevant to the questions that were posed in the beginning.

Q3 Describe, in your own words, the result of each experiment and indicate how it addressed a specific question.

Conclusions

The conclusions should show how data from each experiment are relative to a question. How have the results contributed to understanding? Have models been modified? Have theories been tested and found inadequate? In short, how has the paper increased knowledge?

Students are often told that suggesting directions for further research is a part of evaluating a paper, or to indicate if they agree with the paper’s conclusions (and why or why not). These seem to me to fall closer to the realm of criticism than understanding. But certainly, indicating potential errors in gathering data and interpreting models is a part of understanding a paper.

Q4 Describe how the experimental results have or have not answered each of the questions posed by the paper.

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