How Scientists Do Science?

How They Walk Through the Mazes of Science?

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How…

- Broadly speaking,
  - **science is interested in answering questions and acquiring knowledge concerning the observable universe**.
- Therefore,
  - Science can be done by the help of scientific research

Goals of Scientific Research

- Once again to repeat, **science is interested in answering questions and acquiring knowledge concerning the observable universe**.
- Various research methods are used in an attempt to satisfy these interests.
- Many researchers agree that the goals of scientific researchare: description, prediction, and explanation/understanding.

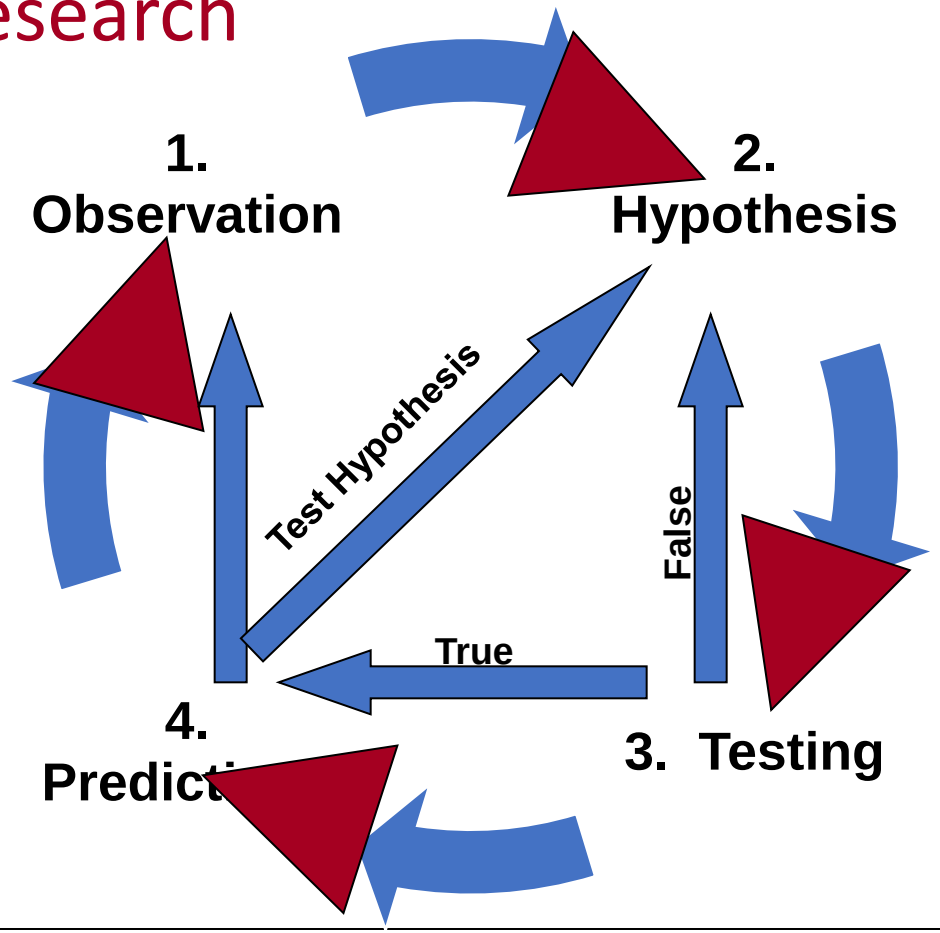
Understanding Research Methodology: What is *Methodology?*

- Methodology is scientific techniques used to collect and evaluate data.

The Scientific Method involves a series of steps that are used to investigate a natural occurrence.

Scientific Method of Research

Four Steps:



- If the experiments prove the **hypothesis** to be true, it becomes a **theory** or **law** of nature.
- If the experiments prove the hypothesis to be false, the hypothesis must be rejected or modified.
- The scientific method used properly should give us **predictive power** (to understand phenomena which have not been tested).

5 Steps to the Scientific Method

- **There are five steps to the *scientific method*.**

  - **Identify a problem.**
  - ***Research* the problem.**
  - **Formulate a hypothesis.**
  - **Conduct an experiment.**
  - **Reach a conclusion.**

7 Steps of Scientific Method

1. Problem/Question
2. Observation/Research
3. Formulate a Hypothesis
4. Experiment
5. Collect and Analyze Results
6. Conclusion
7. Communicate the Results

We shall take a closer look at these steps and the terminology you will need to understand before you start a science project.

Steps of the Scientific Method

1. **Problem/Question**: Develop a question or problem that can be solved through experimentation.

Steps of the Scientific Method

2. **Observation/Research**: Make observations and research your topic of interest.

an act of recognizing and noting a fact or occurrence often involving measurement with instruments

- *Experiments* performed in the laboratory.
- *Experiments* gained from knowledge of the literature.

Keys to Implementation in your Research:

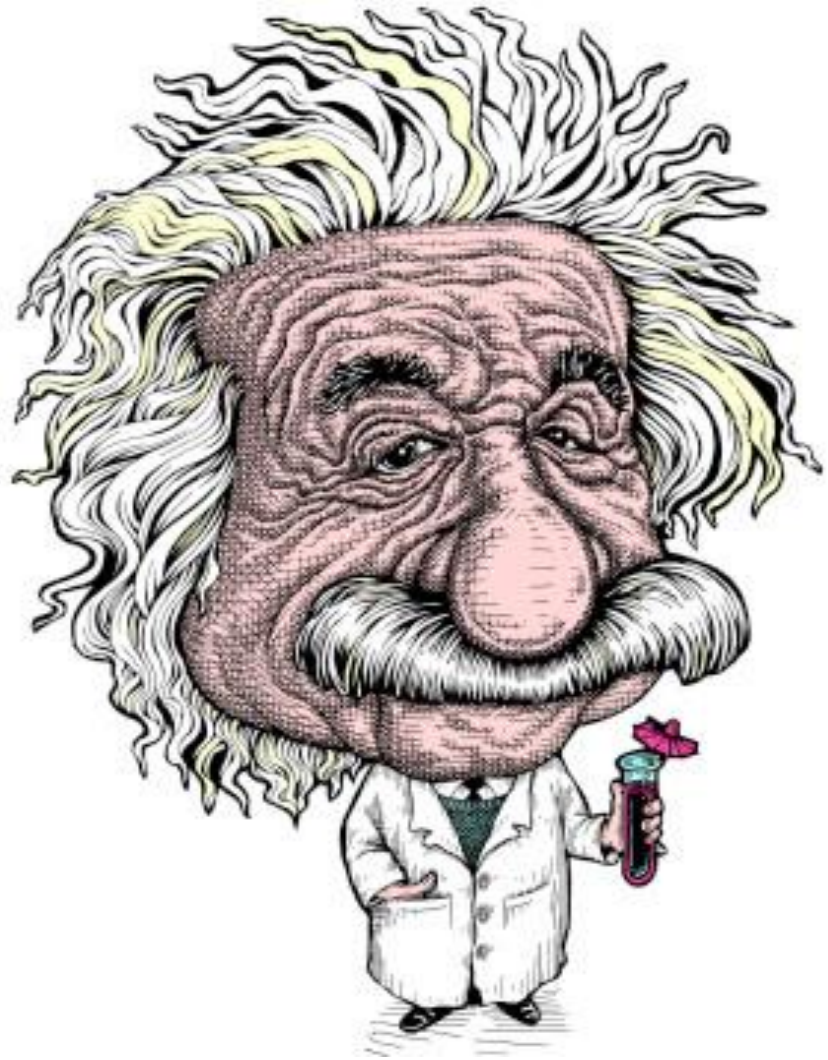
Sorting Observations (from Literature Searches):

Useful	Not Useful (Yet!)
Contains unanswered questions which you think you have means of addressing	Proclaims research has explained everything (does not contain unanswered questions)

Formulate Hypothesis!

Note Results (in report format- optional) for future use in confirming/denying your hypothesis (once your hypothesis is found)!

Do you remember the next step?



Steps of the Scientific Method

3. Formulate a Hypothesis: tentative assumption made in order to draw out and test its logical or empirical consequences

Therefore predict a possible answer to the problem or question.

Example: If we increase the Ach level, then parasympatomimetic activity will increase.

Keys to Implementation in your Research:

- Good Hypothesis can be TESTED with Experiment or Calculation.
- This requires A LOT of thought and reading--- leap from observation to hypothesis. It is worth the effort because after thinking this through, you are ready to go into the laboratory (which is the FUN part of research)!

Suggestions (no one can tell you HOW to do this, you have to develop this skill):
1. Couple archival **journal reading** with your in-class theory.
2. Couple archival **journal reading** with your **'common sense'** or intuition about the way things should be in the system that you are studying.
3. Follow a **logical reasoning** about what you are reading with scientific and/or mathematical basis (use drawings and diagrams to help your understanding).
4. **Write up your thoughts and opinions** either in report format (or in a way which you can follow within one notebook).

Steps of the Scientific Method

4. Experiment: Develop and follow a procedure.

Include a detailed materials list.

The outcome must be measurable (quantifiable).

•Experimental Testing –

to be assigned a standing or evaluation on the basis of tests **2 :** to apply a test as a means of analysis or diagnosis

Keys to Implementation in your Research:

- Good TESTS will prove or disprove your hypothesis.
- Experimental Tests can be performed within the realm of computing.
- Consider all alternatives. Experiment may not disprove all (but may disprove only parts) of your hypothesis. That is still alright to perform. Carefully note which aspects of your hypothesis this experiment will test.
- Consider the availability of instrumentation to perform your tests.

Suggestions:
• See websites for list of available equipment. • If you do not know (or have never heard of it), learn about that equipment, what it measures, what it can fabricate, what is does, etc • Ask questions! Schedule meetings with appropriate people in charge of equipment to inquire about capabilities and terms/conditions for use.

•Predictions–

to declare or indicate in advance; *especially* **:** foretell on the basis of observation, experience, or scientific reason

Keys to Implementation in your Research:

- Good Predictions can also be tested against your hypothesis.
- Consider going back to the basics (textbook theory) to development of a new experimental model/construct which will help to make predictions about more subject details than you can reasonably test.

Suggestions:
• You may begin thinking about predictions as soon as you have a hypothesis, however, if your hypothesis is proven false, your prediction will also fail!

Steps of the Scientific Method

5. **Collect and Analyze Results:** Modify the procedure if needed.

Confirm the results by retesting.

Include tables, graphs, and photographs.

Steps of the Scientific Method

6. Conclusion: Include a statement that accepts or rejects the hypothesis.

Make recommendations for further study and possible improvements to the procedure.

Steps of the Scientific Method

7. Communicate the Results: Be prepared to present the project to an audience.

Expect questions from the audience.

Scientific Approaches to Knowledge

- General approach: Empirical
- Observation: Controlled
- Reporting: Unbiased
- Concepts: Clear definitions
- Instruments: Accurate/precise
- Measurement: Reliable/repeatable
- Hypotheses: Testable
- Attitude: Critical

Empirical vs. Deterministic

Empirical	Deterministic
Based on experimental observation	Based on first *principles approach*!

Understanding Research Methodology 2: Systematic Empiricism

- Scientific research relies on theuse of empirical data for acquiring knowledge.
- Empiricism means making use of observation and experience.
- Science goes beyond the use of the empiricism normally used in everyday life.
- However, scientific research employs *systematic empiricism*.

Key Points Related with Systematic Empiricism

- **KeyPoints**
- Empirical data (making use of observation and experience) is important in developing scientific knowledge, but it is not enough.
- **Systematic empiricism (also known as scientific empiricism) is structured in a way tohelp us describe, predict and explain how things work in theworld.**
- Everyday observation, no matter how much is done, does not give us a better understanding of the world.
- **One of the biggest drawbacks of everyday observations is lack of control.**
- Many have suggested the essential ingredient of scientific research is control, which is lacking in everyday observation and experience.

So Many Articles, So Little Time: Scientific Discovery Series

- There are currently about 50 million scholarly journal articles published online
- —with another 2.5 million being added every year.
- Looking in from the outside, one might think researchers would be exuberant over today's overflowing pipeline of scientific content.
- Consider these sobering stats:
    - 1/3 of papers account for 80% of all citations
    - 12% of medical papers are never cited
- To overcome these challenges, it's critical for researchers to choose their search tools wisely—and to understand how they work.

Good News for the Researchers

- That there are plenty of discovery portals to choose from.
- To ensure an efficient and fruitful discovery process, it is critical for researchers to choose their search portals wisely—and to know how to use them effectively.

Top 10 Databases in Scientific Research

(https://www.library.wisc.edu/find/top-10-databases/)

Database Name	Subject Area	
ABI/Inform	Business	(More info…)
Academic Search	General (Multidisciplinary)	(More info…)
Google Scholar	General (Multidisciplinary)	(More info…)
JSTOR	General (Multidisciplinary)	(More info…)
LEXISNEXIS Academic	News	(More info…)
PsycINFO	Psychology	(More info…)
PubMed/Medline	Medicine	(More info…)
ScienceDirect	Science (Multidisciplinary)	(More info…)
Scopus	General (Multidisciplinary)	(More info…)
Web of Science	General (Multidisciplinary)	(More info…)

Top 11 Trusted (And Free) Search Engines For Scientific and Academic Research

1. **Google Scholar** (http://scholar.google.com/):
2. **CiteSeer^x** (http://citeseerx.ist.psu.edu):
3. **GetCITED** (http://www.getcited.org/):
4. **Microsoft Academic Research** (http://academic.research.microsoft.com/):
5. **Bioline International** (http://www.bioline.org.br/):
6. **Directory of Open Access Journals** (http://www.doaj.org/):
7. **PLOS ONE** (http://www.plosone.org/):
8. **BioOne** (http://www.bioone.org/):
9. **Science and Technology of Advanced Materials** (http://iopscience.iop.org/1468-6996/):
10. **New Journal of Physics** (http://iopscience.iop.org/1367-2630):
11. **ScienceDirect** (http://www.sciencedirect.com/):

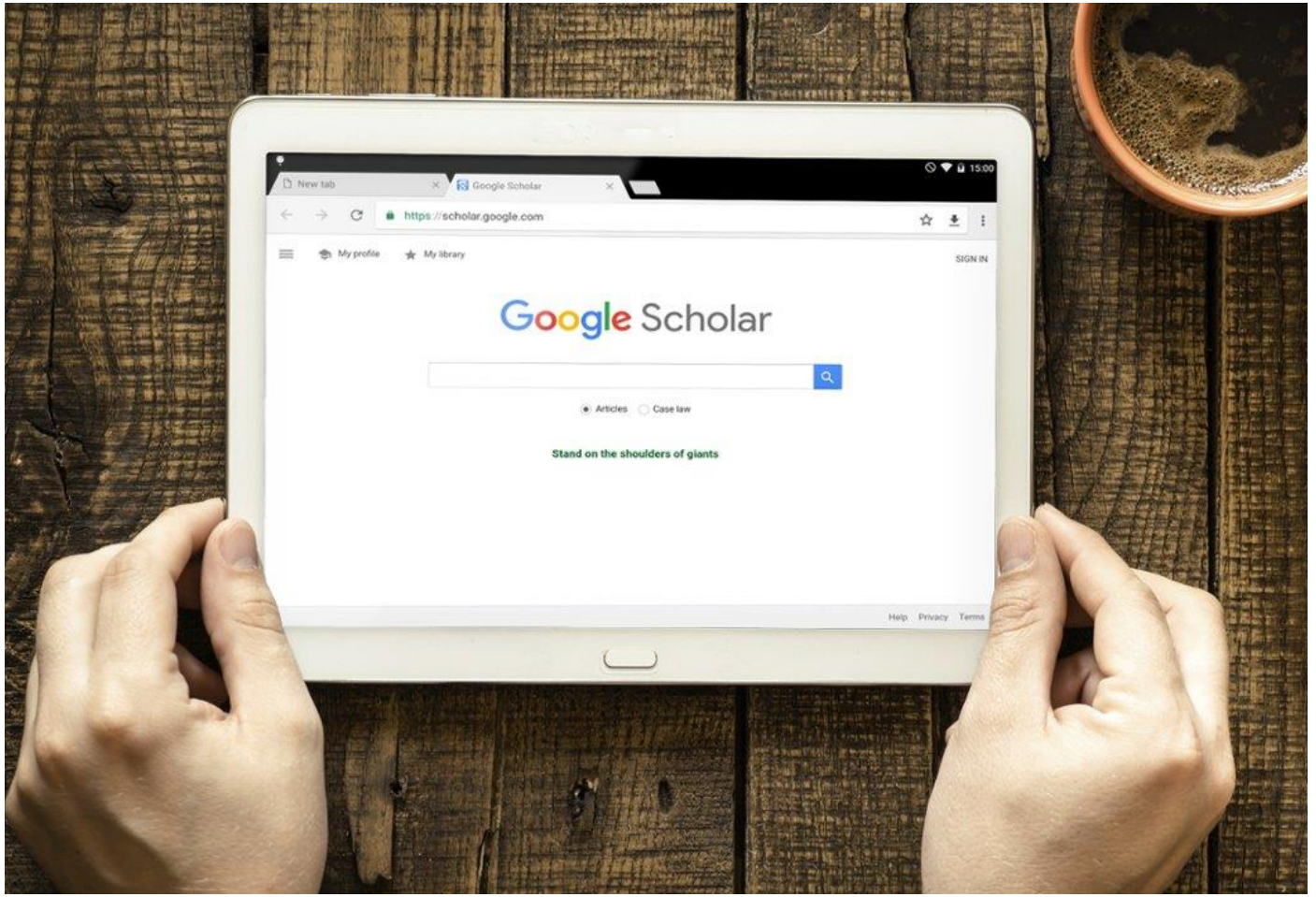
- https://www.emergingedtech.com/2013/12/top-11-trusted-and-free-search-engines-for-scientific-and-academic-research/

Key Facts Every Researcher Should Know About PubMed

IN A NUTSHELL:

- Maintained by the U.S. National Library of Medicine (NLM),
- PubMed is a free search engine focused on biomedical content discovery.
- As of March 2018, PubMed contained more than 28 million citations from MEDLINE, life science journals, and online books.
- MEDLINE is a bibliographic database for life sciences and biomedical information maintained by NLM.
- It currently indexes citations from 5,200 journals in 40 languages.
- PubMed is the premier go-to research portal for any type of medical research.

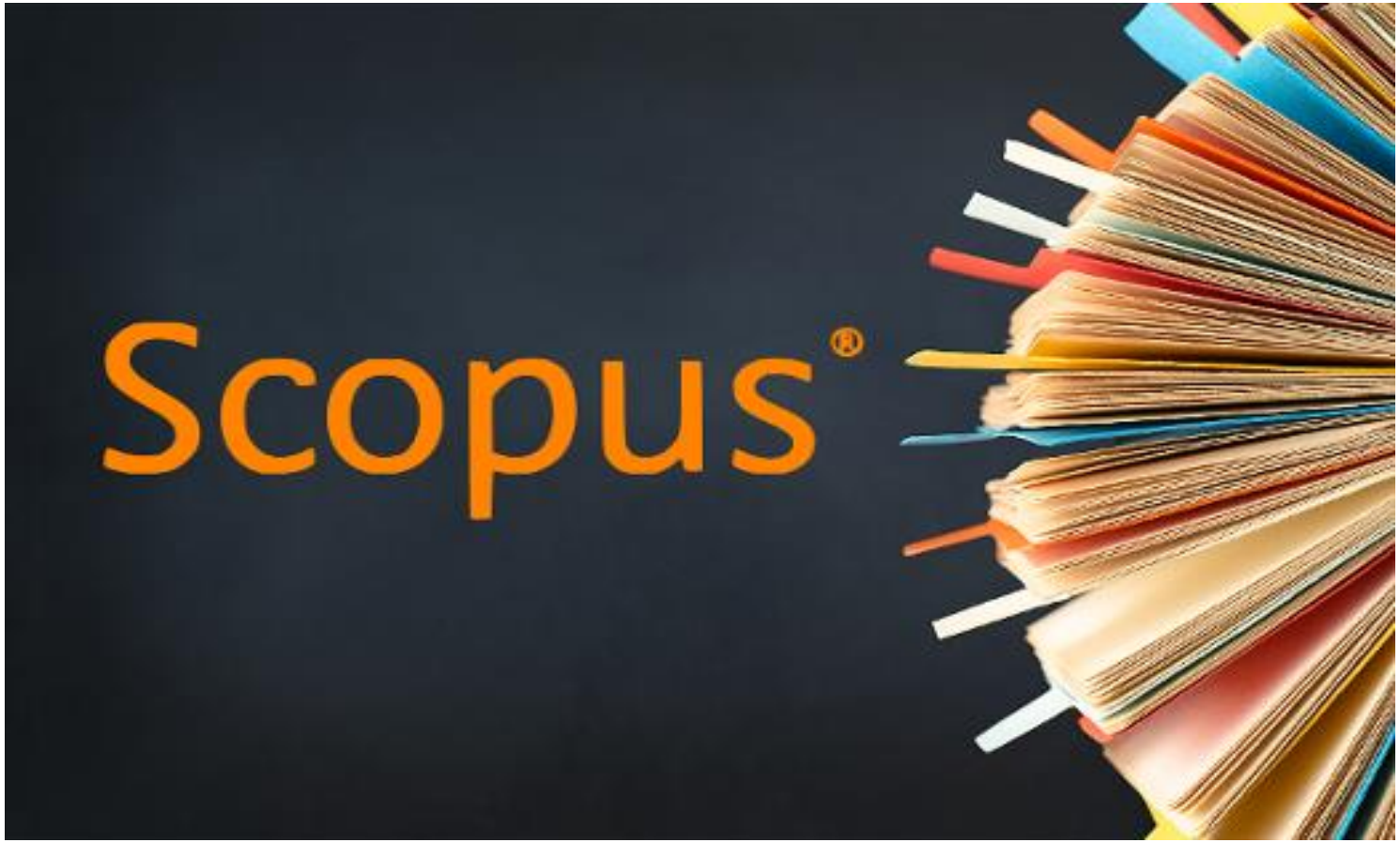
Key Facts Researchers Should Know About Google Scholar



IN A NUTSHELL:

- Google Scholar is a free search engine that uses Google's familiar, intuitive interface.
- It indexes scholarly literature across a wide range of disciplines and publishing formats (articles, abstracts, books, conference proceedings, court opinions, theses, and more) estimated at roughly 160 million citations.
- Because it lets you search an array of disciplines and sources in a single list, you can quickly get a feel for the scholarly discussion around a specific topic.
- As such, Google Scholar is an excellent resource for performing high-level, preliminary research. It's also useful for uncovering authors and publications relevant to your research.

Key Facts Every Researcher Should Know About Scopus



IN A NUTSHELL:

- Owned by Elsevier, Scopus is a multidisciplinary database.
- It covers peer-reviewed journals, books, conference proceedings, and patents across the fields of science, technology, medicine, social sciences, and arts and humanities.
- According to Elsevier, Scopus is ‘The largest abstract and citation database of peer-reviewed literature.’
- Updated daily, the database contains 64+ million records and 22,000+ peer-reviewed journals from 5,000 international publishers.
- Among the health science titles indexed, Scopus claims 100% coverage of MEDLINE, EMBASE, and Compendex.

Thank you for your attention...