How to conduct a proper Scientific Research ??

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Outlines

تعريف البحث العلمي و أساليب و مناهج البحث العلمي

القياسات و التجارب و التأكد من النتائج

أخلاقيات البحث العلمي

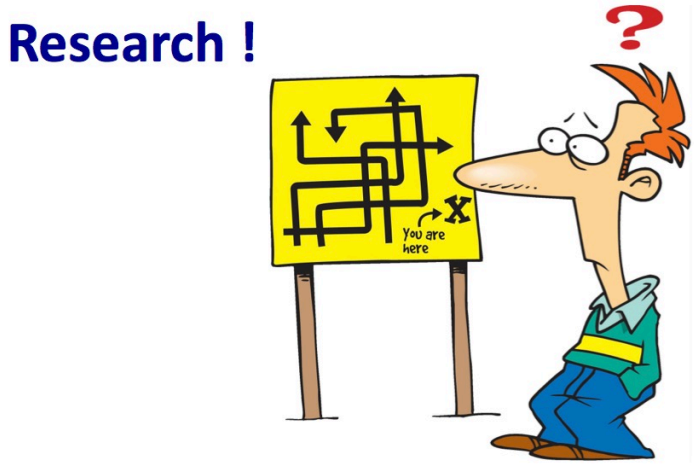
التوثيق و الكتابة

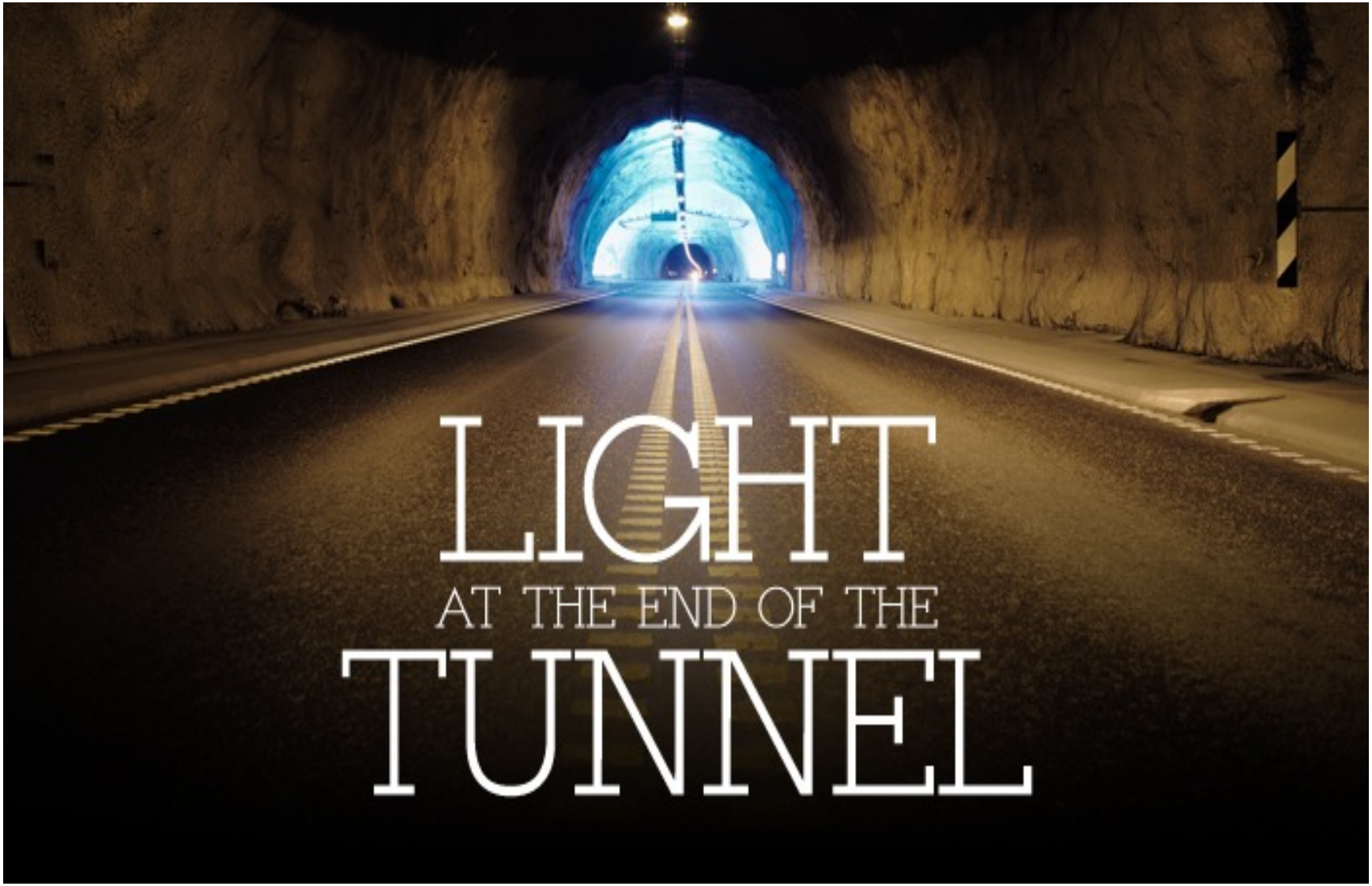
Main Reference

All Slides / photographs included in this lecture have been drawn from course

https://egyptscholars.org/scientific-research-guide/

تعريف البحث العلمي
أساليب و مناهج البحث العلمي



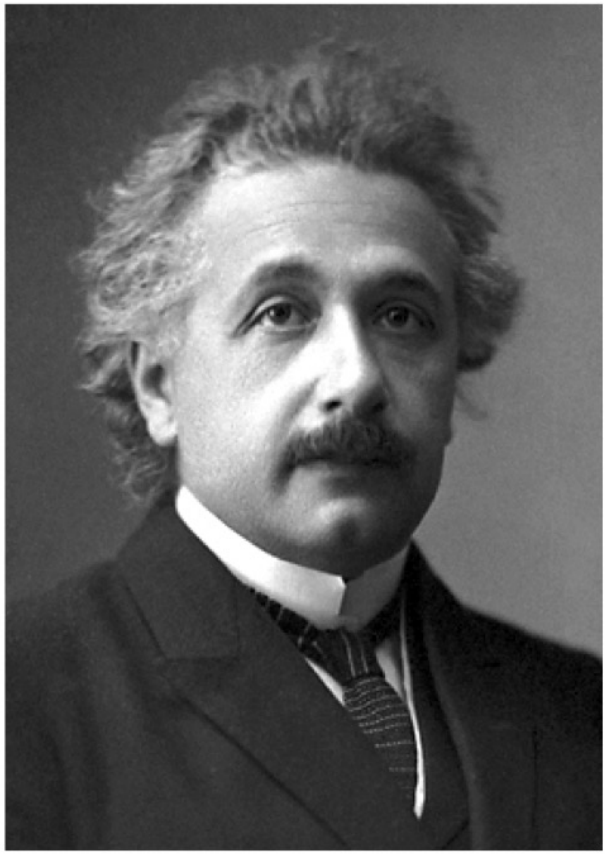

LIGHT
AT THE END OF THE
TUNNEL

What is research?

- Research is simply the process of finding solutions to problems after a thorough study and analysis.
- It comprises a series of well-thought-out and carefully executed steps that are designed with the goal of finding an answer to a certain question.
- So, the 1st step in any research is to identify as clearly and specifically as possible a problem that needs to be resolved.
- Once a problem is clearly defined, we can gather information, do experiments if necessary and analyze the data to come up with a decision/solution.

“If I knew what I was doing, it wouldn't be called REsearch”.
– Albert Einstein

«لوكنا نعلم ما نقوم به، فلن يُطلَق على ذلك بحثًا، أليس كذلك؟»



What is research?

- Research is what we do when we have a question or a problem we want to resolve
- We may already think we know the answer to our question already
- We may think the answer is obvious, common sense even
- But until we have subjected our problem to rigorous scientific scrutiny, our 'knowledge' remains little more than guesswork or at best, intuition.

“Science, in the very act of solving problems, creates more of them”. – Abraham Flexner

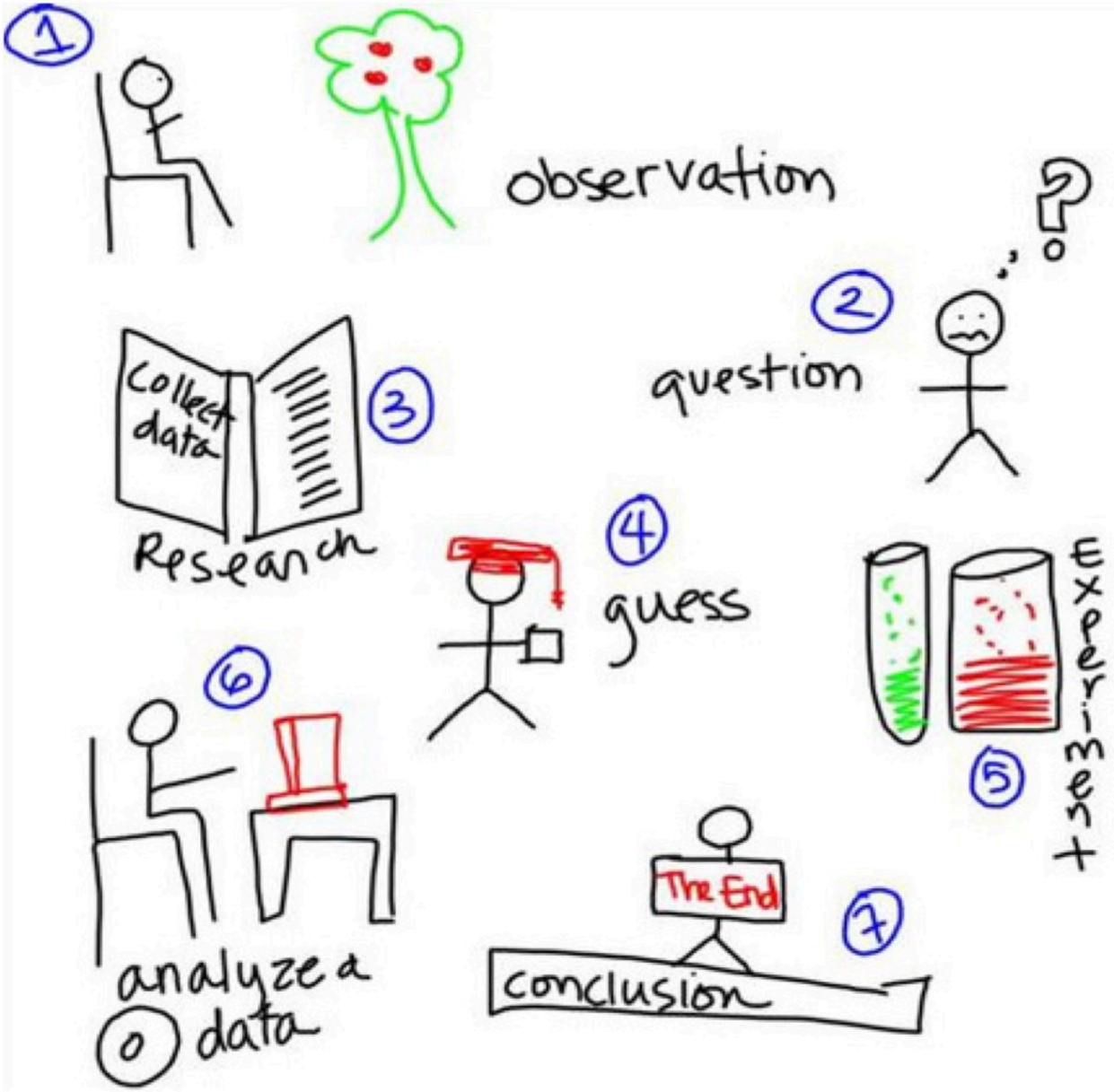
«مع أن الهدف من العلم هو حل المشاكل، إلا أنه يخلق المزيد منها!»

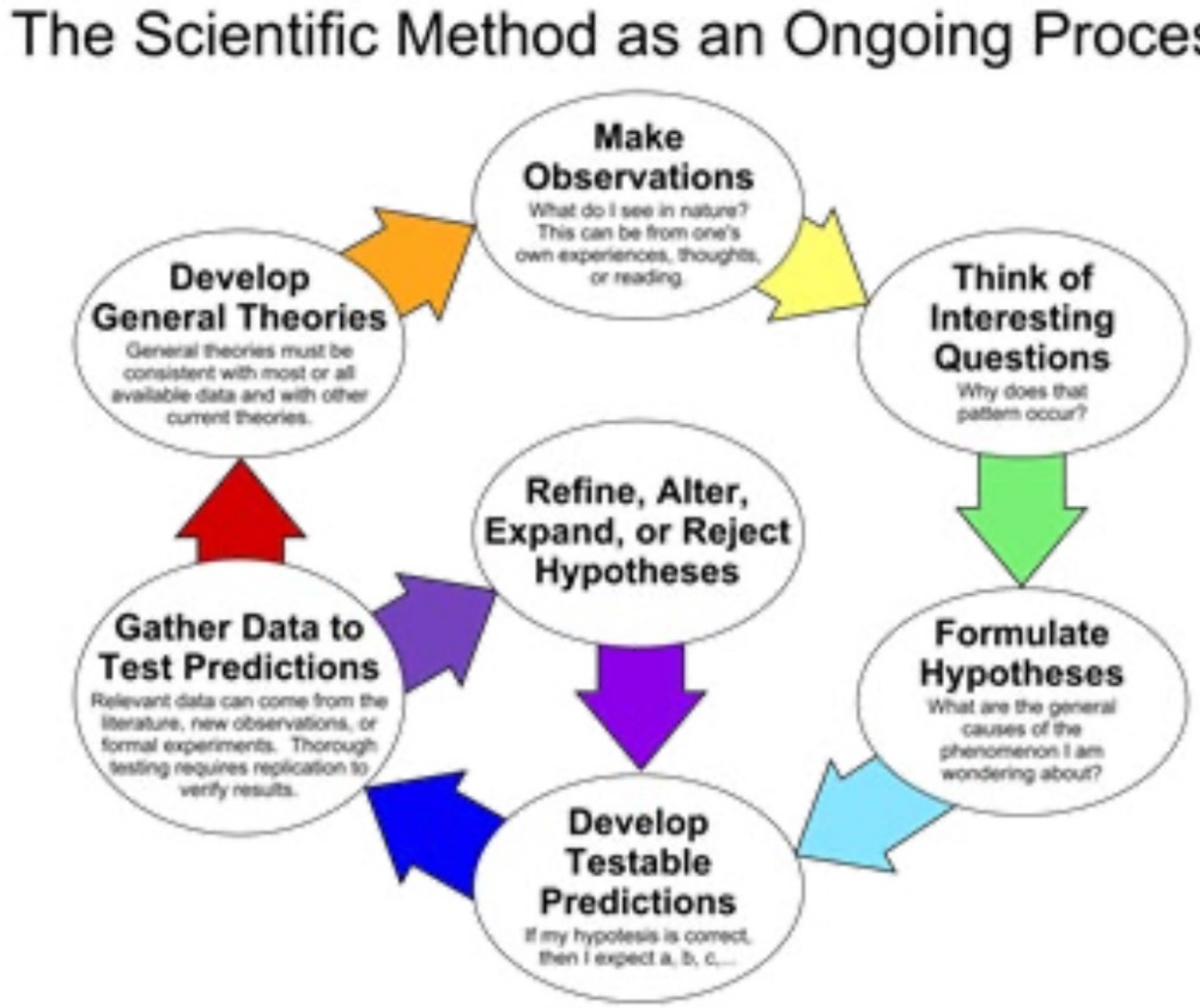
- إبراهام فلكسنر، أحد الرواد الذين أسسوا للتعليم الطي في أمريكا

Basic Vs. Applied research

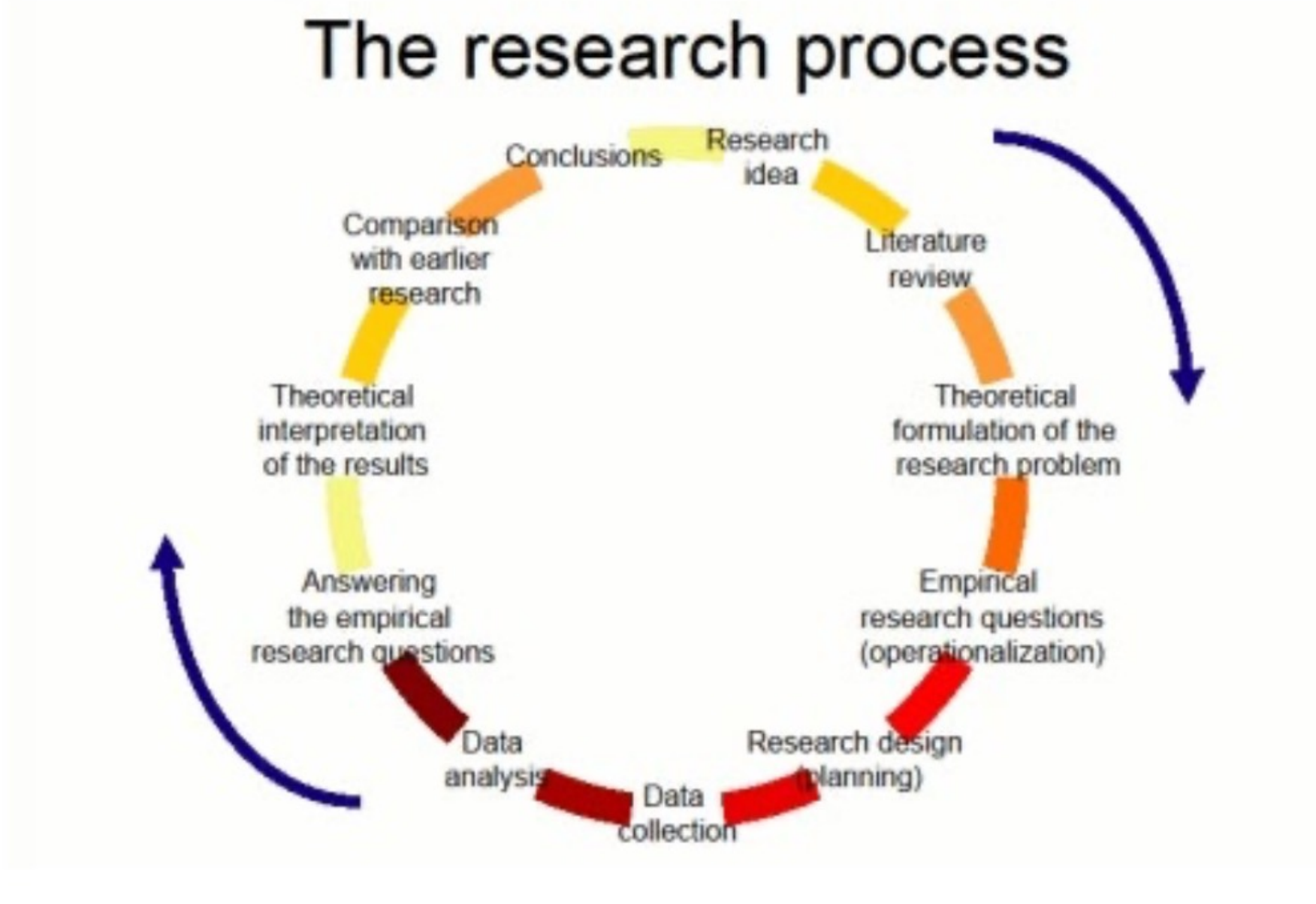
- **Basic:** when the solution to a research problem has no apparent application to any practical problem in the world, but only is to generate a body of knowledge to satisfy the scholarly interest of the researcher
- **Applied:** when the solution to a research problem does have practical consequences e.g. a disease needs therapy
- People value both types of research
- The pursuit of knowledge for its own sake to know more and understand better is one humanity's highest calling

Scientific method





شكل ٣ البحث العلمي كعملية مستمرة (Source: Wikipedia. Image by: Garland, Jr., Theodore)



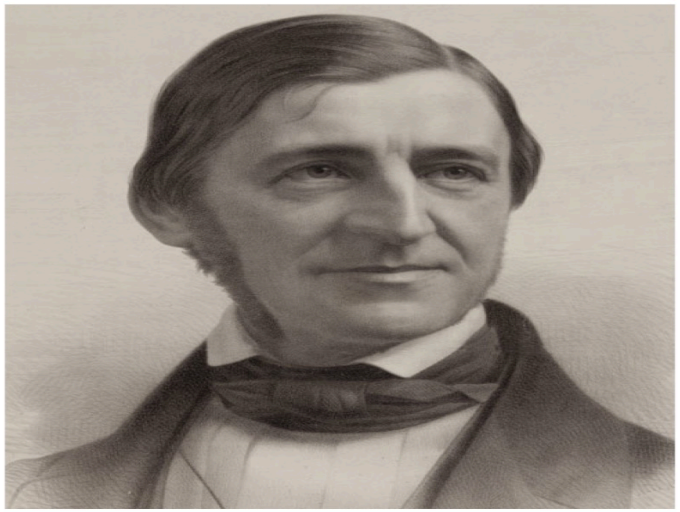
(Baltimore County Public Schools ٢٠١٠ © Source: BCPS One. Copyright) ل ١ خطوات العملية البحثية

The scientific method involves 7 steps:

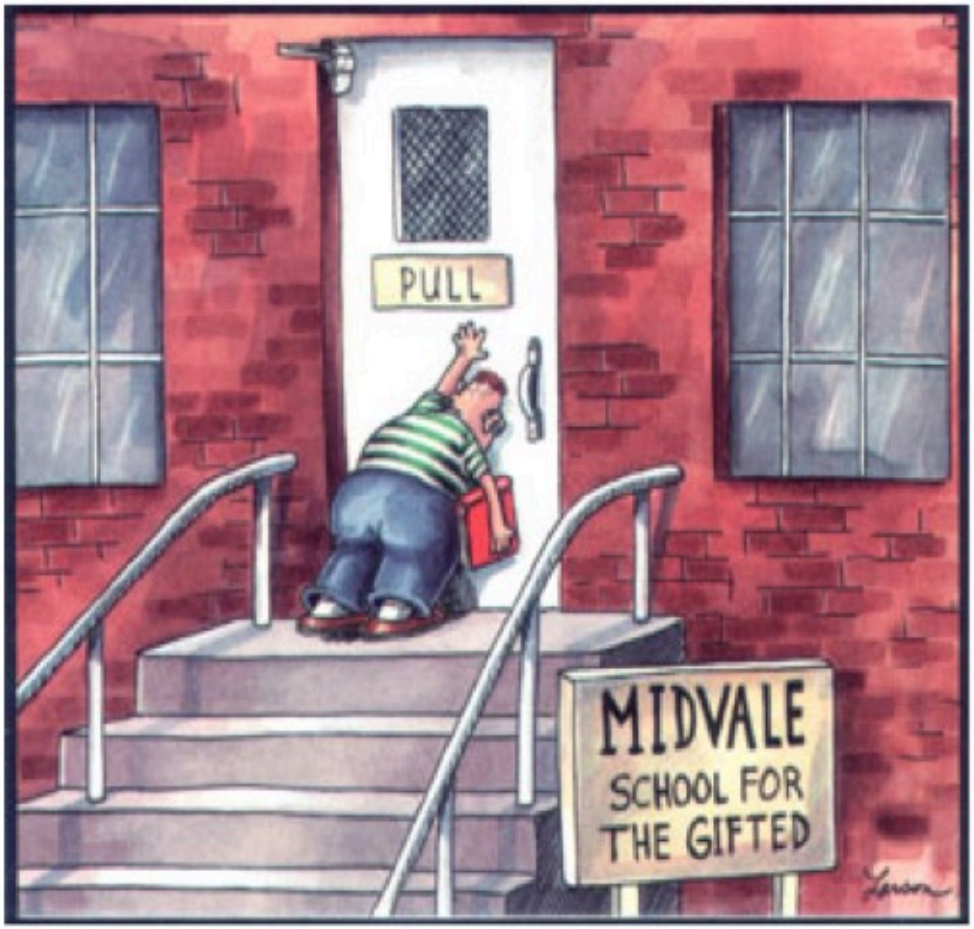
1. Make an observation/identify a broad problem area
2. Define the problem statement that includes the general objective(s) and research question(s)
3. Gather information/literature search
4. Make a guess/develop hypotheses
5. Define methodology and do the experiment
6. Data collection and analysis
7. Data interpretation/make conclusions

1- Make an observation

“Men love to wonder, and that is the seed of science.”
— Ralph Waldo Emerson



2- Define your problem statement and formulate a research question



The process of addressing a practical problem typically looks like this:

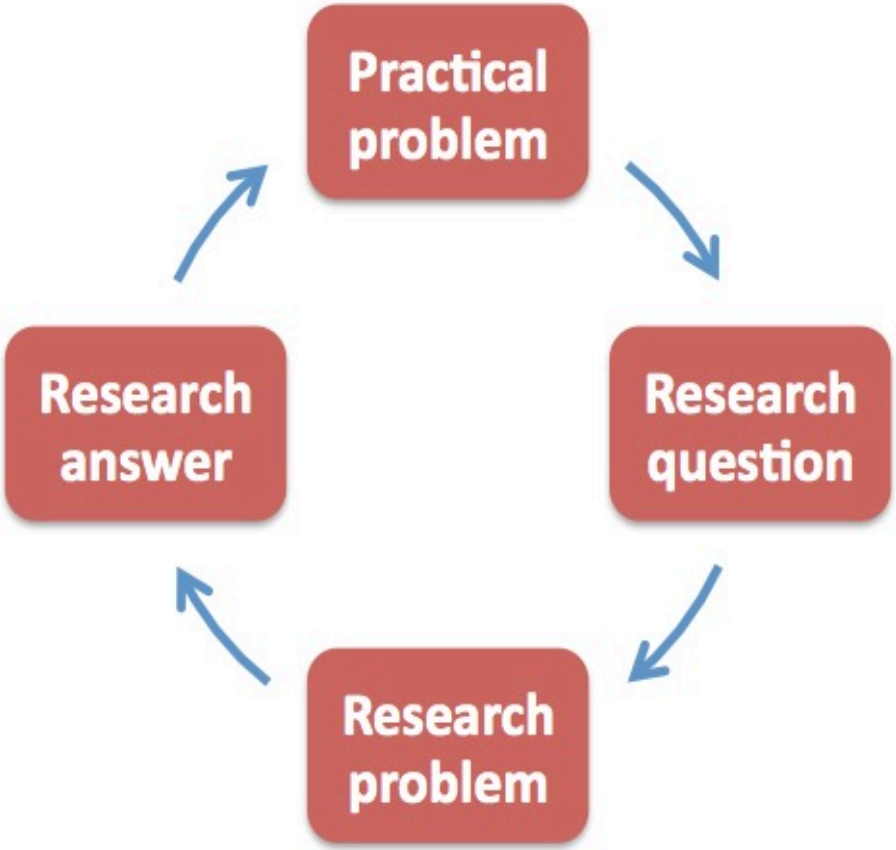
- **Practical problem:** virus causes disease
- **Research question:** how can I stop it from causing disease?
- **Research problem:** I don't know if there is a chemical compound that can do this job for me and I need to find a way to screen compounds
- **Research answer:** compound X is effective
- **Application:** treat disease

Research : why questions

- **Research goes beyond description and requires analysis**

- **Research looks for explanations, relationships, comparisons, predictions, generalizations and theories**

Steps for addressing a problem

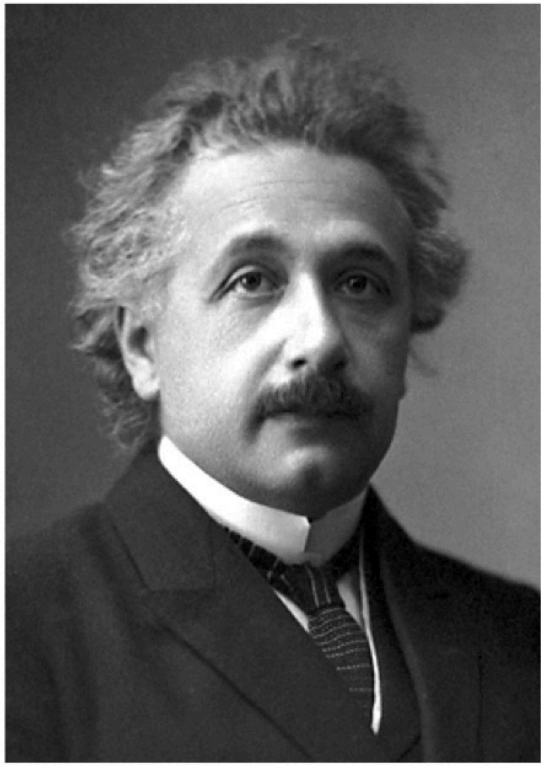


Practical Vs. Research problem

- **A practical problem:** a condition in the world that makes us unhappy because it costs us time, money, pain, etc. = A problem that a normal person tries to avoid

- **A research problem:** incomplete knowledge = A problem that a researchers would seek out or invent if necessary! If he has no research problem to work on, he has no job!

“Student: Dr. Einstein, Aren't these the same questions as last year's physics final exam?
Dr. Einstein: Yes, but this year the answers are different.”
— Albert Einstein



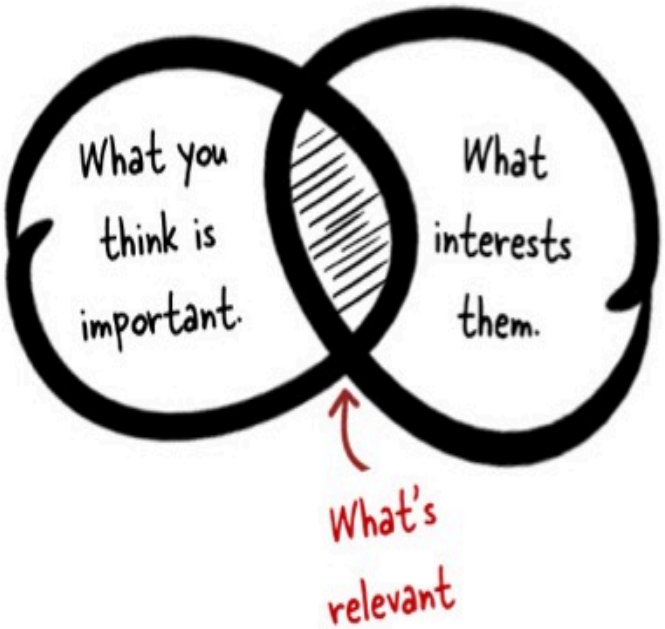
What is a problem statement?

- A problem statement addresses both the "why" (the specific aim or purpose of the study) and the "what" (the central research question or a set of questions) of the research

- There are three key criteria for a good problem statement; it should be:
  a) relevant
  b) feasible
  c) interesting

A problem statement is relevant if:

1. Nothing is known about a topic; you will have to prove that your claim is right!
2. Much is known about the topic, but the knowledge is scattered and not integrated
3. Much research on the topic is available, but the results are (partly) contradictory



A problem statement is feasible if:

- You are able to answer the research questions within the restrictions of the research project (time, money and know-how)
- Carve out a research question that you can answer!
- Bear in mind that no one can solve a problem in a 10-page paper; your paper will help us better understand the problem and gets us closer to a solution!

Why your problem statement should be interesting?

- Research is a time-consuming process and you will go through many ups and downs before you present the final version of your research report

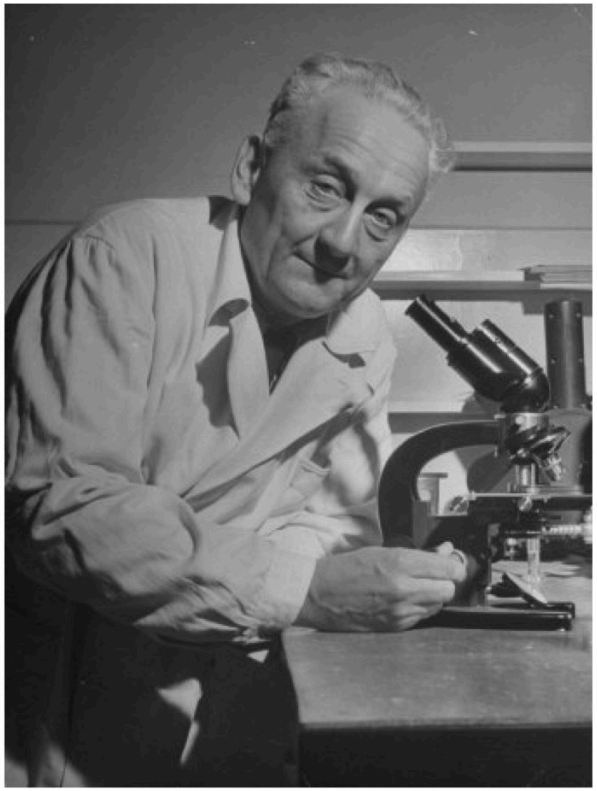
- It is therefore vital that you are genuinely interested in the problem statement you are trying to answer, so that you can stay motivated throughout the entire research process

Formulate a strong problem statement

- Start by asking: so what? What makes this research worth doing? Why should my research question grab the attention of my audience?
- You can work toward a problem statement in 3 steps:
  1. Name your topic: I am trying to learn about/study
  2. Add a question (to yourself):
     - ✓ I am studying .... because I want to find out how or why
  3. Motivate your question (to others):
     - ✓ The answer to my question will solve a problem that is significant to a wider community of readers
     - ✓ If this problem was left unresolved = trouble

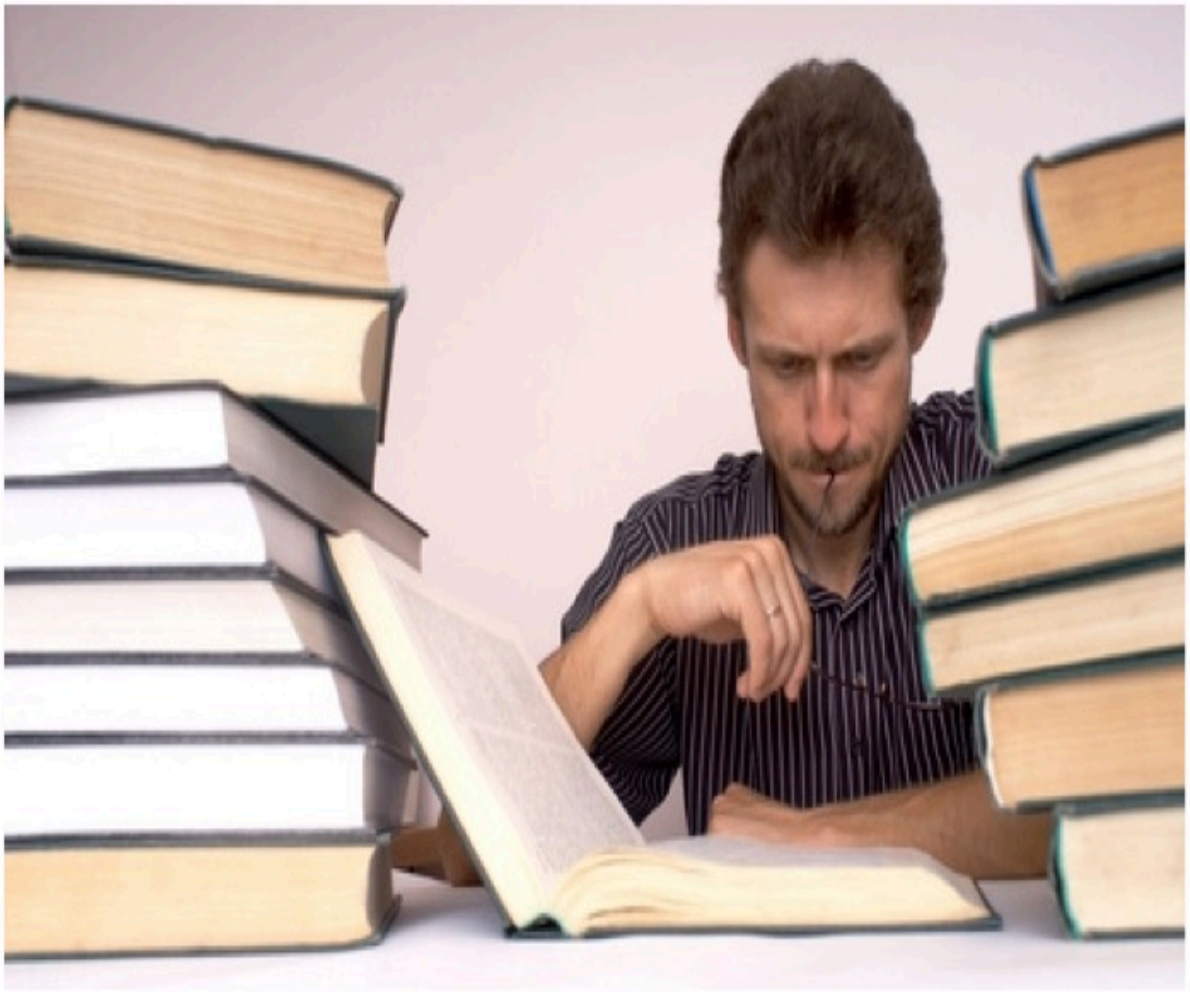
“Research is to see what everyone else has seen, but thinking what no one else has thought.”

— Albert Szent-Gyorgyi



«البحث العلمي هو أن ترى ما يراه الآخرون، وفي نفس الوقت تفكر فيما لم يفكر به أحد.» -ألبرت جيورجي، عالم فسيولوجي مجري مكتشف فيتامين سي، والحاصل على نوبل عام 1973

3- Gather information/Literature search



What is literature?

- Literature – the body of knowledge available to you or what is already known and written down that is relevant to your research project.

- A literature review is a process that involves the identification of published work on the topic of interest, the evaluation of this work in relation to the problem, and the documentation of this work.

Examples for resources

- Journal articles
- Text books
- Theses
- Conference proceedings
- Academic databases
- Government or business reports
- Encyclopedia (in print, not Wikipedia!)
- Internet

Be extra cautious when using the internet!

- Internet is unregulated!
- You can obtain material that can help you in formulating your research question, but very hard to find reliable sources for serious research!
- Always prefer a printed source, unless it is an online journal or supplement.
- Google scholar can help you with academic literature.

Criteria for selecting sources:

- Screen your sources for reliability
- Is it relevant to your hypothesis?
- Is it published by a reputable press?
- Peer-reviewed?
- Author reputable?
- Source up-to-date?

3 uses for resources:

1. **Read for a problem:** if you are having trouble formulating a research problem or question. Look for inspiration. Look for gaps in knowledge, unresolved issues or new lines of research.
2. **Read for an argument:** when you see how other researchers address similar problems, you can learn how to address yours too.
3. **Read for evidence**: find data that you can use to support your claim.

A literature review ensures that:

1. Put your research into context
2. You do not run into the risk of "reinventing the wheel"
3. You look at your problem from several angles
4. You didn't miss an important variable
5. You know the research methods

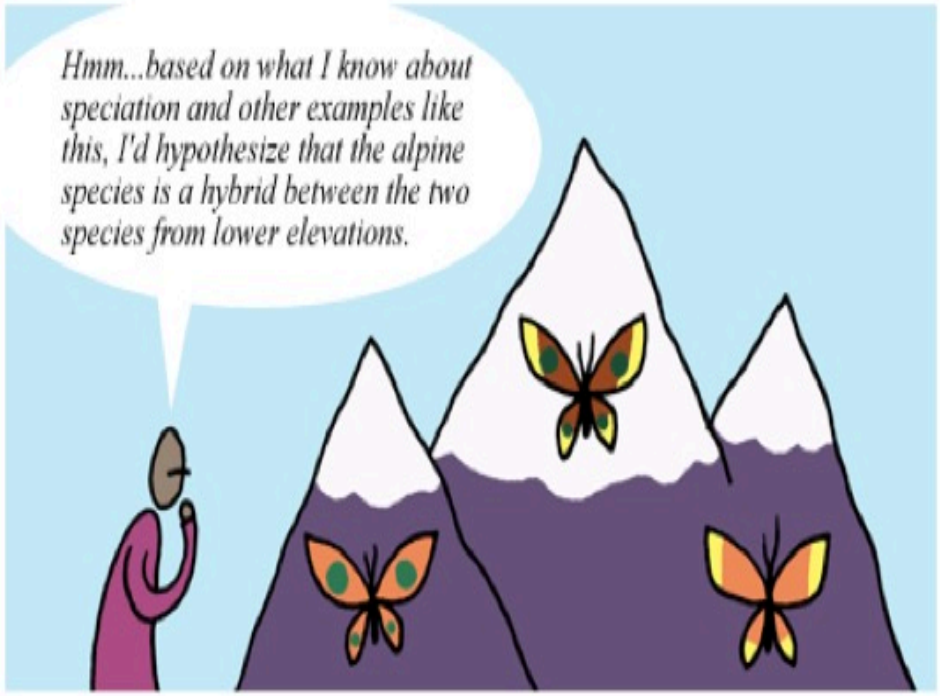
Don't reinvent the wheel!

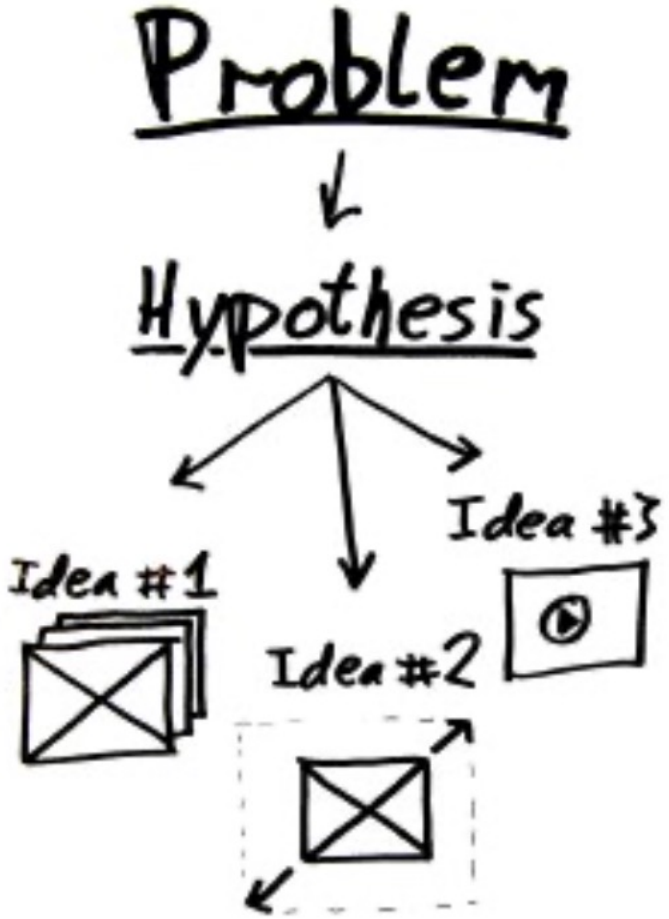
Read critically!

- You don't have to agree with the conclusions in a source!
- Don't accept a claim just because it is mentioned in a paper published in a respected journal, particularly if the claim isn't well supported. People can sometimes misinterpret their own data!
- Look for weaknesses in other researchers arguments; yes nobody is prefect!
- Get the context right!

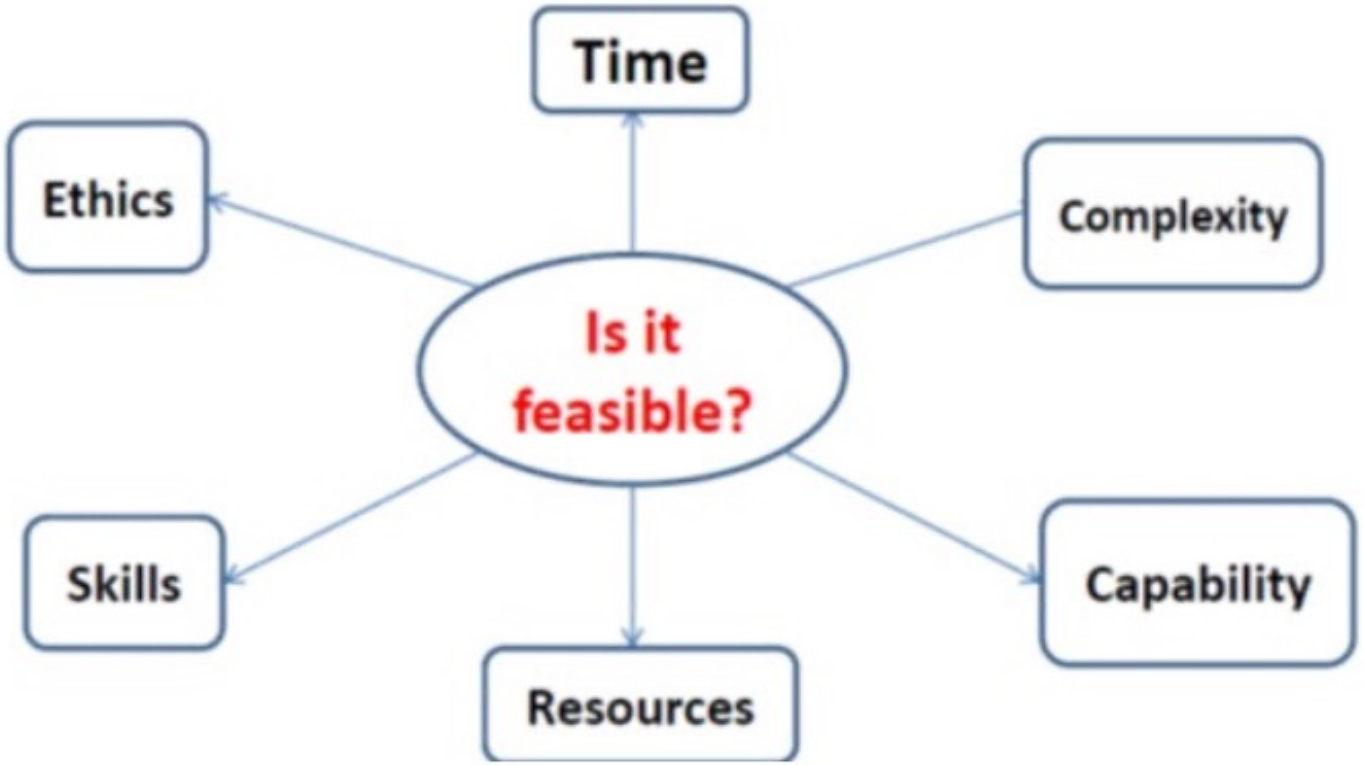
4- Hypothesis development

- A hypothesis can be defined as a tentative, yet testable, statement, which predicts what you expect to find in your empirical data.
- A scientific hypothesis must meet two requirements: testable and falsifiable.
- By testing the hypotheses, it is expected that solutions can be found to correct the problem encountered.





شـكل ٢ البحـث العلمـي يبـدأ بمشـكلة نفكـر لهـا في
حـل مبنـي عـلى فرضيـة (- Source: Baymard.com
(Copyright to Baymard Institute



شكل ٤ المعايير التي توضع في الاعتبار عند اختبار الفرضية

5- Define methodology & do the experiment

القياسات و التجارب و التأكد من النتائج

What your research supposedly looks like:

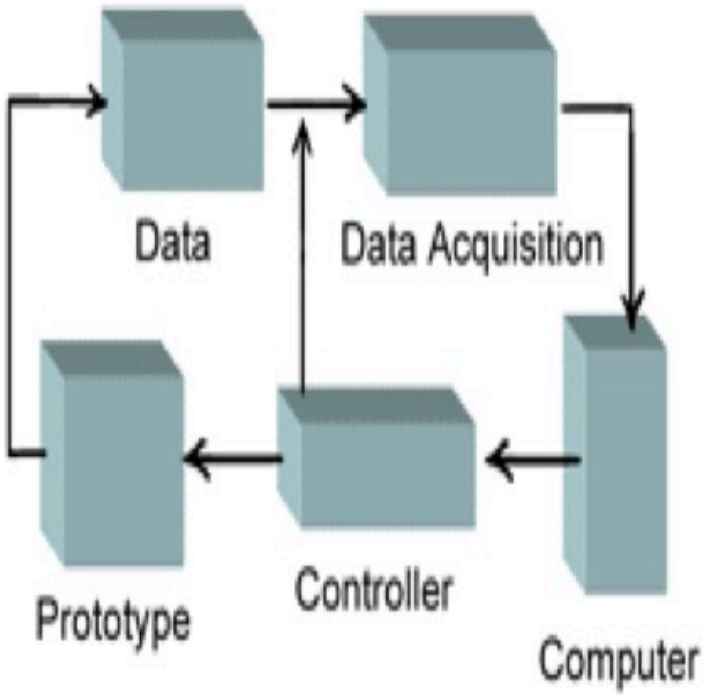


Figure 1. Experimental Diagram

What your research *actually* looks like:

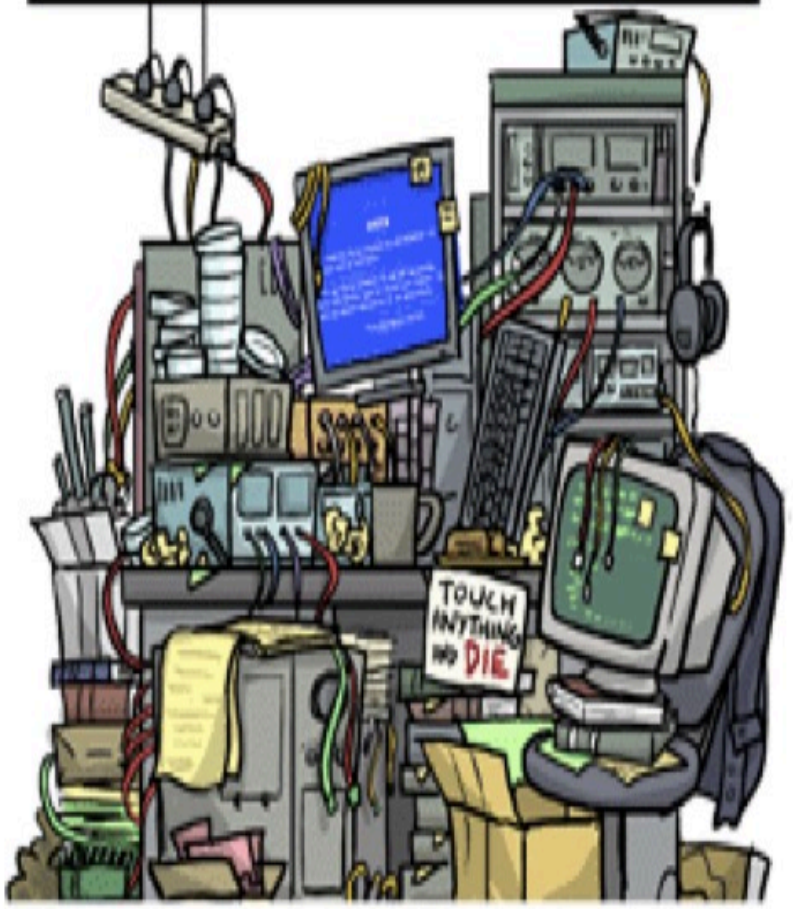


Figure 2. Experimental Mess

- **Prepare for your experiment:**

1. Materials list.
2. step-by-step procedures instructions.
3. data chart , tables & observations.

▪ Define Your Variables :

▪ **Variables** are anything that might impact the outcome of your study.

▪ **Types :**

1. Independent variables
2. Dependent variables
3. Controlled variables

- **Standardize Your Procedures**

Follow The 3 Principles of Experimental design

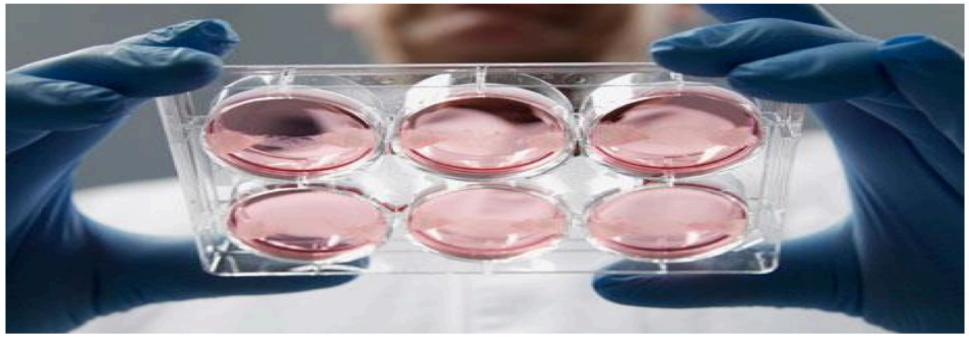
(1) Randomization :

Every experimental unit have the same chance.

(2) Local control :

Control of all factors except the ones about which we are investigating.

(3) Replication :



6- Data collection and analysis

- **Data :**

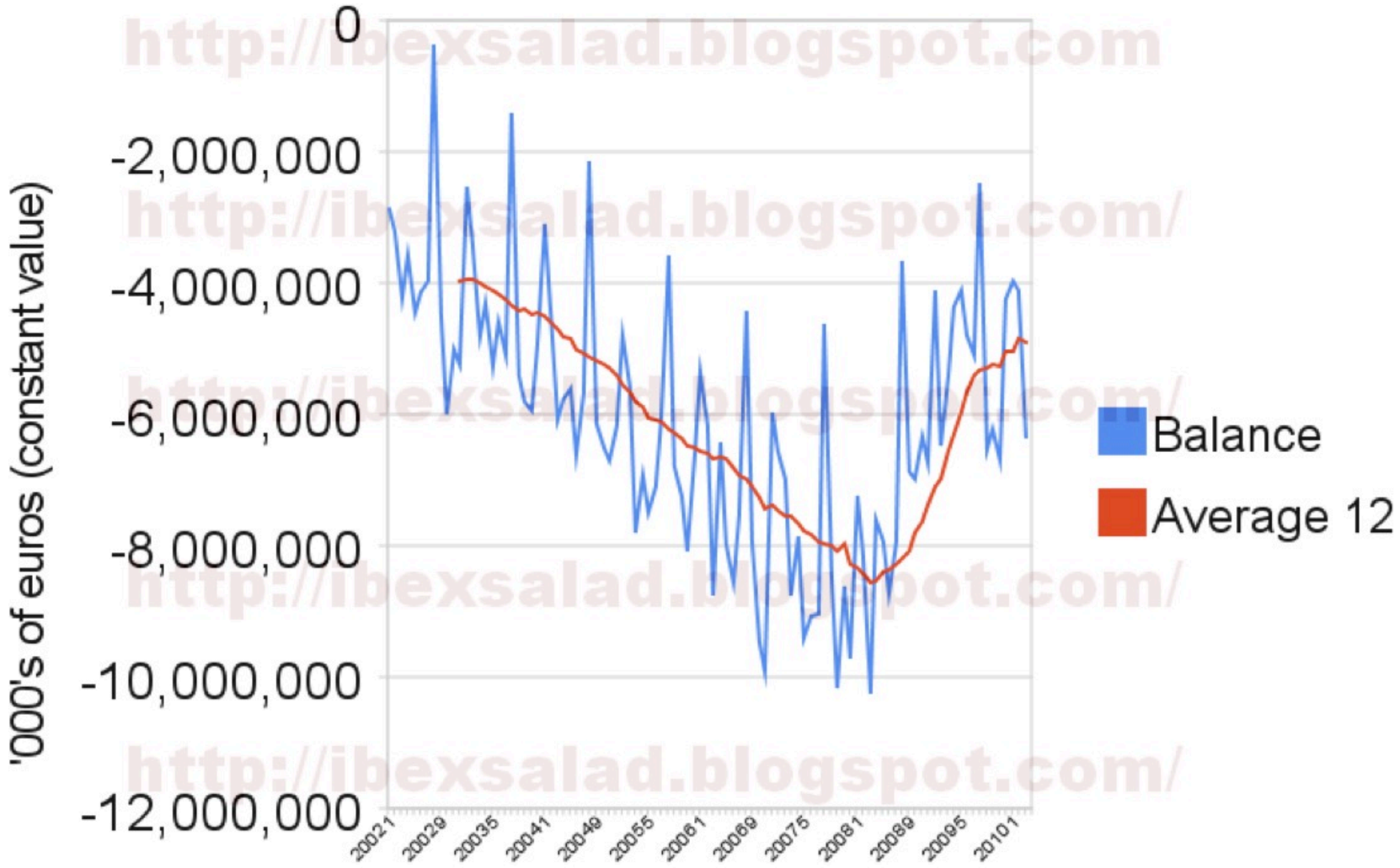
Facts gathered through your observations.

- **Analyze :**

Look for patterns.

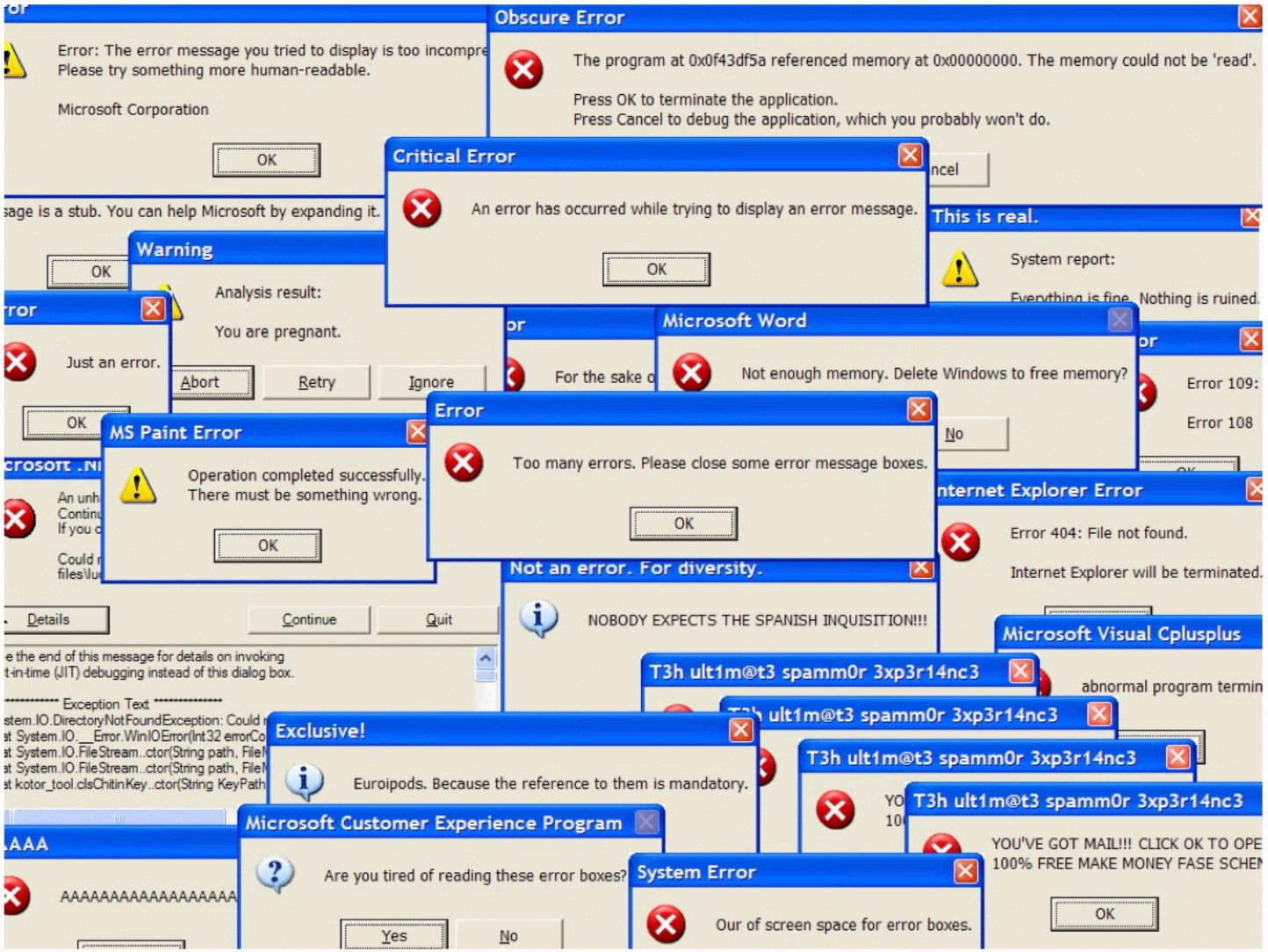
Make a picture (graph) with your collected data or write an analysis.

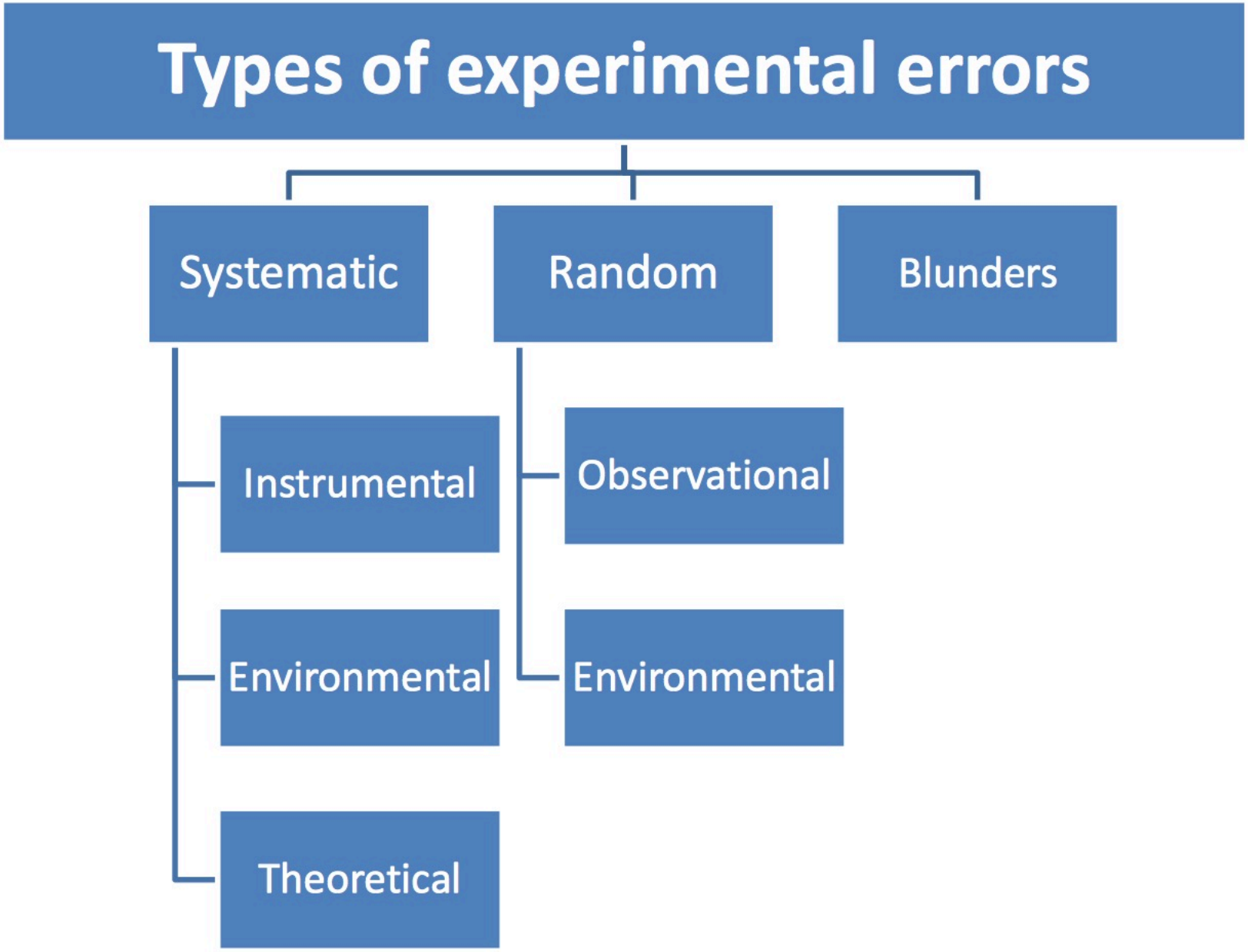
Spain - Balance of Trade in Goods



source: www.meh.es

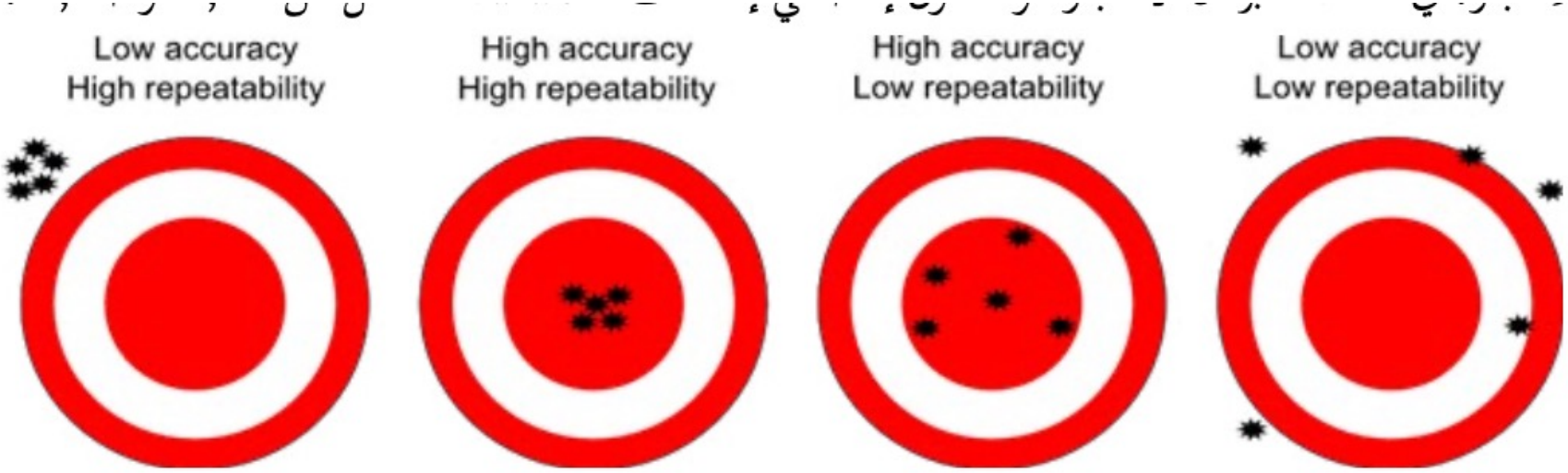
Errors !!!


Obscure Error
The program at 0x0f43df5a referenced memory at 0x00000000. The memory could not be 'read'.
Press OK to terminate the application.
Press Cancel to debug the application, which you probably won't do.
Error: The error message you tried to display is too incompre
Please try something more human-readable.
Microsoft Corporation
OK
Critical Error
An error has occurred while trying to display an error message.
OK
This is real.
System report:
Warning
Analysis result:
You are pregnant.
Abort
Retry
Ignore
Just an error.
Microsoft Word
Not enough memory. Delete Windows to free memory?
No
Error
Too many errors. Please close some error message boxes.
OK
MS Paint Error
Operation completed successfully.
There must be something wrong.
OK
Internet Explorer Error
Error 404: File not found.
Internet Explorer will be terminated.
Not an error. For diversity.
NOBODY EXPECTS THE SPANISH INQUISITION!!!
Microsoft Visual Cplusplus
abnormal program termin
Details
Continue
Quit
T3h ult1m@t3 spamm0r 3xp3r14nc3
Exclusive!
Euroipods. Because the reference to them is mandatory.
Microsoft Customer Experience Program
Are you tired of reading these error boxes?
Yes
No
System Error
Our of screen space for error boxes.
YOU'VE GOT MAIL!!! CLICK OK TO OPE
100% FREE MAKE MONEY FASE SCHE
OK


Types of experimental errors
Systematic
Random
Blunders
Instrumental
Environmental
Theoretical
Observational
Environmental

«معدل الخطأ»

P value



شكل ٣ الدقة مقابل التكرار (Source: yuriystoys.com)

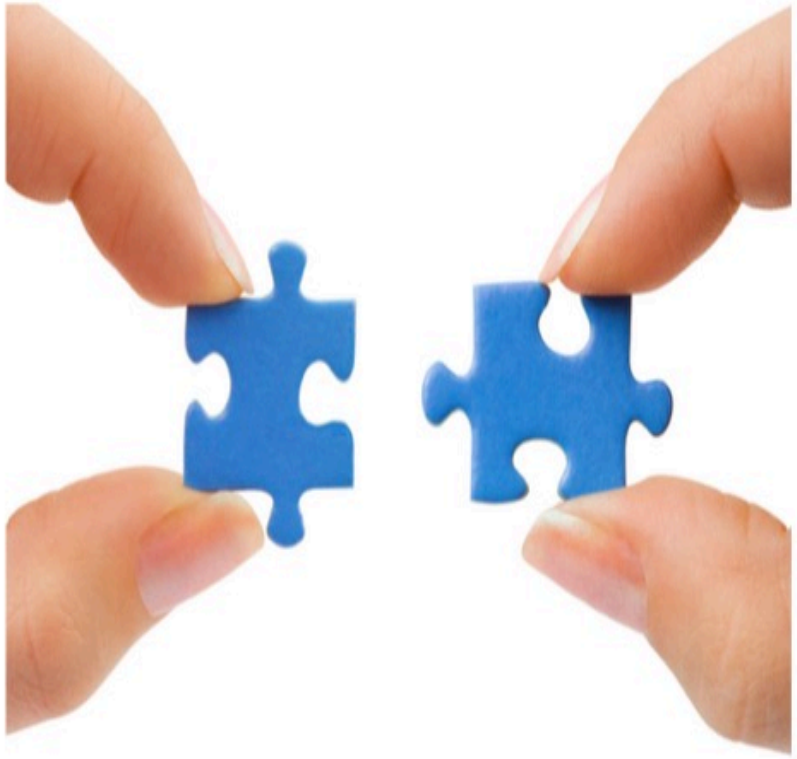
في العادة نعتبر أن الاختبار ذو مدلول إحصائي إذاكانت
أقل من 0,05 أو 0,01 الـP-value

أما الثقة فتعني أن نتائجك ُيحتمل أن يصل مدى صحتها إلى 95% ومدى خطئها إلى 5%، أو باللغة الإحصائية إلى مقدار الاحتمال الذي نثق به، (Confidence Intervalأن تحدد مستوى دلالة تجاربك. وتشر فترة الثقة (فقولنا ثقة مقدارها 99% يعني أن هناك فرصة قدرها 99 من 100 بأن تضم الفترة قيمة المتوسط الحقيقي للمجتمع.

7- Data interpretation / Make conclusions

- Decide whether your hypothesis is supported or not by the results.

- Hypotheses that are not supported allow you to refine your theory by thinking about why they were not supported. You can then test your refined theory in future research.



Conclusion

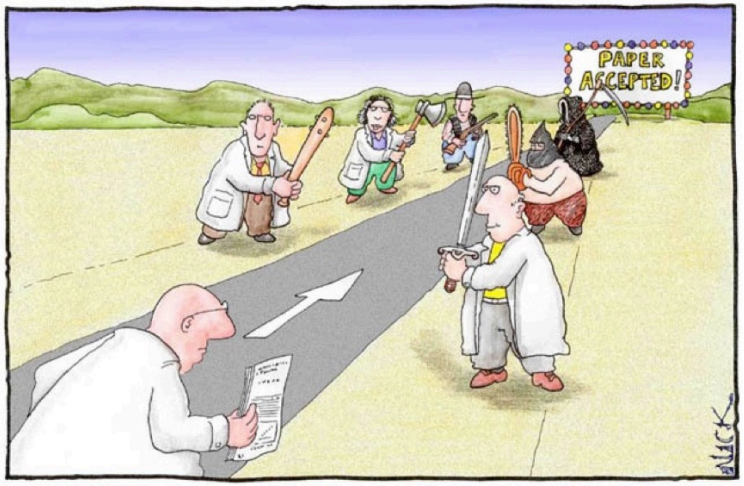
- It is a summary of what you've learnt.
- You examine your results to see if its support your hypothesis.
- If it doesn't you may need to go back fix some problems in your experiment and experiment again.

Part II

التوثيق و الكتابة

Publications

Technical Writing: Structure



your ideas and results with others.

e your procedures to others so they
ıt it.

communicate include :
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أخلاقيات البحث العلمي

Plagiarism

Plagiarism

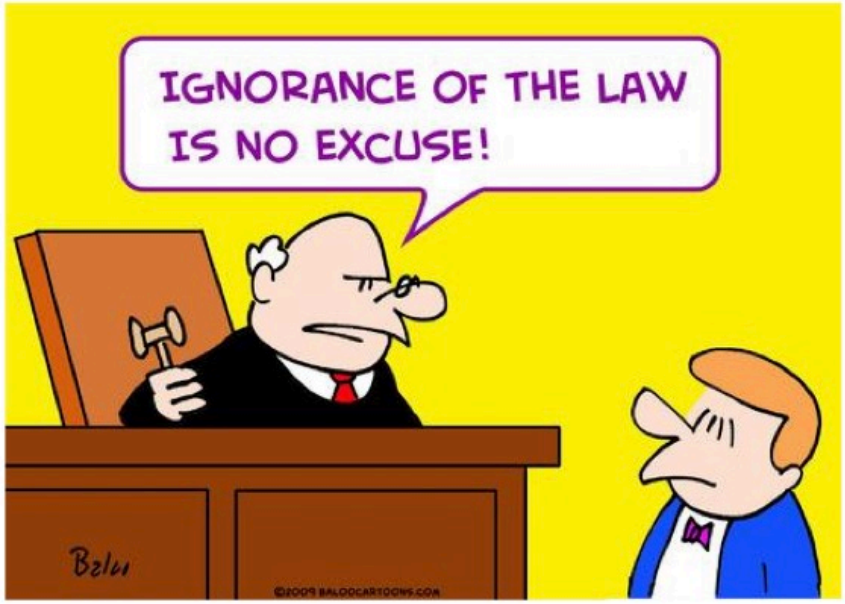
- This is the worst thing that can happen to a researcher!
- Deliberate plagiarism is a crime!

What is plagiarism?

- Plagiarism comes from the Latin word *plagiarius*, which means kidnapper ☺ (Menager-Beeley & Paulos, 2006).
- Plagiarism can occur when copying, summarizing, paraphrasing, or citing common knowledge (Roig, n.d)., facts, ideas, and/or words *without* giving credit
- You cannot copy/past more than 1-2 sentences
- If you want to use a figure/picture from somewhere else:
  - Get permission first
  - Give credit

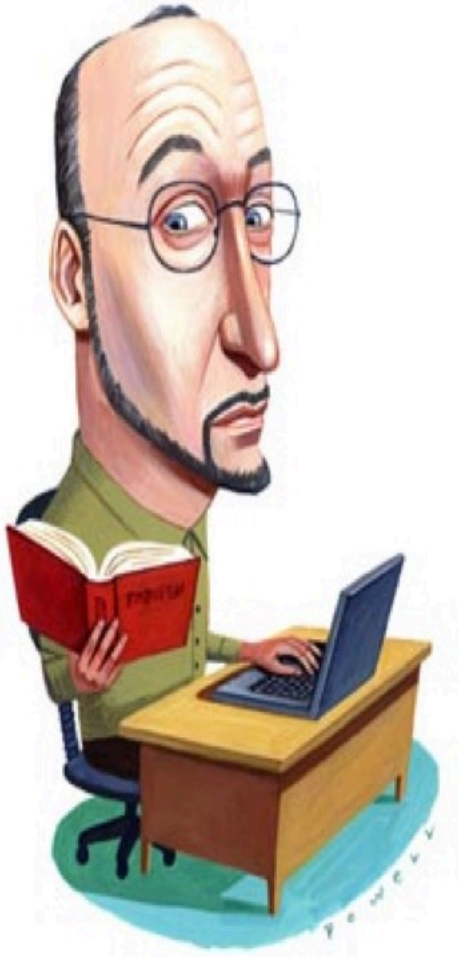
Unintentional plagiarism

- Sometimes it is done in good faith, out of carelessness, or out of ignorance when you are not sure about what to cite, how and when



Plagiarism defined

- You plagiarize, intentionally or not, when you use someone else's words, arguments or ideas without giving credit to that person, misleading your readers to think that those words or ideas are yours



How to Avoid Plagiarism

شكل ٢ الأسباب الخمس الرئيسية لاتباع أخلاقيات البحث العلمي (Source: elsevier.com/ethics)

THANK YOU!

Thank You

Dr. Mohab Abd-Alhameed Mangoud

Associate Professor of Wireless Communications

University of Bahrain, College of Engineering,

Department of Electrical and Electronics Engineering,

http://mangoud.com

How to do good research, get it published and get it cited!

Eamonn Keogh

Computer Science & Engineering Department
University of California - Riverside Riverside,
CA 92521 eamonn@cs.ucr.edu

What Makes a Good Research Problem?

- **It is important:** If you can solve it, you can make money, or save lives, or help children learn a new language, or...
- **You can get real data**: Doing DNA analysis of the Loch Ness Monster would be interesting, but…
- **You can make incremental progress**: Some problems are all-or-nothing. Such problems may be too risky for young scientists.
- **There is a clear metric for success**: Some problems fulfill the criteria above, but it is hard to know when you are making progress on them.

Finding Problems/Finding Data

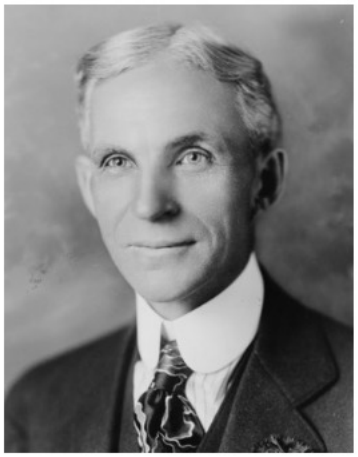
- Finding a good problem can be the hardest part of the whole process.
- Once you have a problem, you will need data…
- As I shall show in the next few slides, finding problems and finding data are best integrated.

Working with Domain Experts I

- Getting problems from domain experts might come with some bonuses
- Domain experts can help with the **motivation** for the paper
  - *..insects cause 40 billion dollars of damage to crops each year..*
  - *..compiling a dictionary of such patterns would help doctors diagnosis..*
  - *Petroglyphs are one of the earliest expressions of abstract thinking, and a true hallmark...*
- Domain experts sometimes have funding/internships etc
- Co-authoring with domain experts can give you credibility.

Working with Domain Experts II

If I had asked my customers what they wanted, they would have said a faster horse



Henry Ford

- Ford focused not on stated need but on **latent need**.
- In working with domain experts, don't just ask them what they want. Instead, try to learn enough about their domain to understand their **latent** needs.
- In general, domain experts have little idea about what is hard/easy for computer scientists.

Finding Research Problems

- Suppose you think idea **X** is very good
- Can you extend **X** by…
  - Making it more accurate (*statistically significantly* more accurate)
  - Making it faster (usually an order of magnitude, or no one cares)
  - Making it an anytime algorithm
  - Making it an online (streaming) algorithm
  - Making it work for a different data type (including uncertain data)
  - Making it work on low powered devices
  - Explaining *why* it works so well
  - Making it work for distributed systems
  - Applying it in a novel setting (industrial/government track)
  - Removing a parameter/assumption
  - Making it disk-aware (if it is currently a main memory algorithm)
  - Making it simpler

Framing Research Problems I

As a reviewer, I am often frustrated by how many people don't have a clear problem statement in the abstract (or the entire paper!)

Can you write a research statement for your paper in a single sentence?

- **X** is good for **Y** (in the context of **Z**).
- **X** can be extended to achieve **Y** (in the context of **Z**).
- The adoption of **X** facilitates **Y** (for data in **Z** format).
- An **X** approach to the problem of **Y** mitigates the need for **Z**.

(An **anytime algorithm** approach to the problem of **nearest neighbor classification** mitigates the need for **high performance hardware**) (Ueno et al. ICDM 06)

If I, as a reviewer, cannot form such a sentence for your paper after reading just the abstract, then your paper is usually doomed.

Tina Eliassi-Rad

I hate it when a paper under review does not give a concise definition of the problem

See talk by Frans Coenen on this topic
http://www.csc.liv.ac.uk/~frans/Seminars/doingAphdSeminarAI2007.pdf

Framing Research Problems II

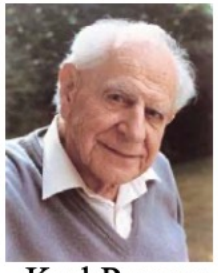
Your research statement should be **falsifiable**

A real paper claims:

> *To the best of our knowledge, this is most sophisticated subsequence matching solution mentioned in the literature.*

Is there a way that we could show this is not true?

Falsifiability (or **refutability**) is the logical possibility that an claim can be shown false by an observation or a physical experiment. That something is 'falsifiable' does not mean it is false; rather, that *if* it is false, then this can be shown by observation or experiment



Karl Popper

Falsifiability is the demarcation between science and nonscience

From the Problem to the Data

- At this point we have a concrete, falsifiable research problem
- Now is the time to get data!

  By "now", I mean months before the deadline. I have one of the largest collections of free datasets in the world. Each year I am amazed at how many emails I get a few days before the SIGKDD deadline that asks "*we want to submit a paper to SIGKDD, do you have any datasets that..* "
- Interesting, real (large, when appropriate) datasets *greatly* increase your papers chances.
- Having good data will also help do better research, by preventing you from converging on unrealistic solutions.
- Early experience with real data can feed back into the *finding and framing the research question* stage.

- Given the above, we are going to spend some time considering data..

Is it OK to Make Data?

There is a **huge** difference between…

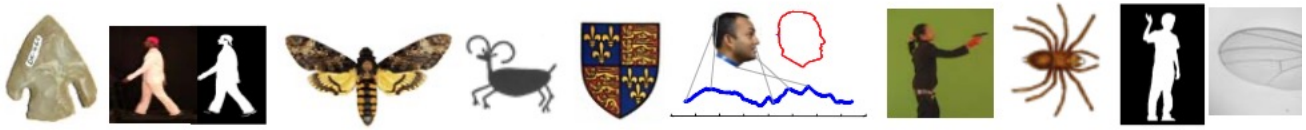
We wrote a Matlab script to create random trajectories

and…

We glued tiny radio transmitters to the backs of Mormon crickets and tracked the trajectories

Photo by Jaime Holguin

Where do I get Good Data?

- From your domain expert collaborators:
- From formal data mining archives:
  - The UCI Knowledge Discovery in Databases Archive.
  - The UCR Time Series and Shape Archive.
- From general archives:
  - Chart-O-Matic
  - NASA GES DISC
- From creating it: 
  - Glue tiny radio transmitters to the backs of Mormon crickets…
  - By a Wii, and hire a ASL interpreter to…
- Remember there is *no* excuse for not getting real data.

Writing the Paper

Samuel Johnson

What is written without effort is in general read without pleasure

- Make a working title
- Introduce the topic and define (informally at this stage) terminology
- Motivation: Emphasize why is the topic important
- Relate to current knowledge: what's been done
- Indicate the gap: what need's to be done?
- Formally pose research questions
- Explain any necessary background material.
- Introduce formal definitions.
- Introduce your novel algorithm/representation/data structure etc.
- Describe experimental set-up, explain what the experiments will show
- Describe the datasets
- Summarize results with figures/tables
- Discuss results
- Explain conflicting results, unexpected findings and discrepancies with other research
- State limitations of the study
- State importance of findings
- Announce directions for further research
- Acknowledgements
- References

Important Words/Phrases II

- **Complexity**: Has an overloaded meaning in computer science
  - *The X algorithms complexity means it is not a good solution (complex= intricate)*
  - *The X algorithms time complexity is $O(n^6)$ meaning it is not a good solution*
- **It is easy to see**: First, this is a cliché. Second, are you sure it is easy?
  - *It is easy to see that P = NP*
- **Actual**: Almost always has no meaning in a sentence
  - *It is an actual B-tree -> It is a B-tree*
  - *There are actually 5 ways to hash a string -> There are 5 ways to hash a string*
- **Theoretically**: Almost always has no meaning in a sentence
  - *Theoretically we could have jam or jelly on our toast.*
- **etc** : Only use it if the remaining items on the list are obvious.
  - *We named the buckets for the 7 colors of the rainbow, red, orange, yellow etc.*
  - *We measure performance factors such as stability, scalability, etc.* *No!*

Important Words/Phrases III

- **Correlated:** In informal speech it is a synonym for "related"
  - *Celsius and Fahrenheit are correlated.* (clearly correct, perfect linear correlation)
  - *The tightness of lower bounds is correlated with pruning power.* *No!*
- **(Data) Mined**
  - *Don't say "We mined the data…", if you can say "We clustered the data.." or "We classified the data…" etc*

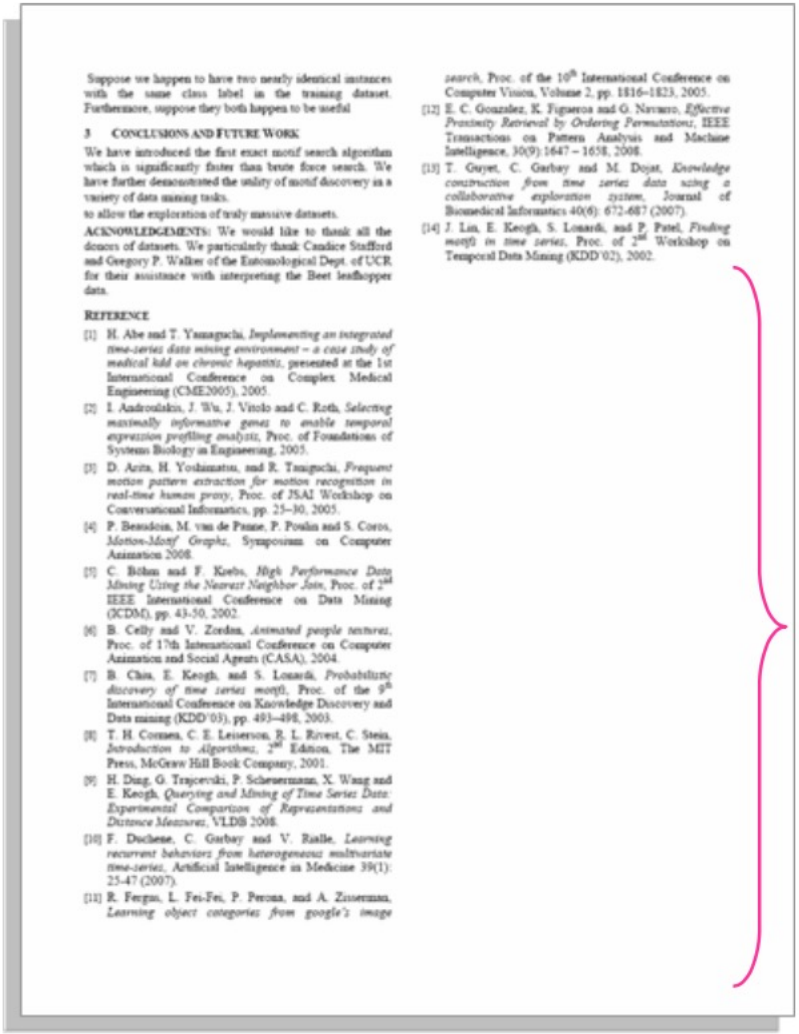
Important Words/Phrases IIII

- **In this paper:** Where else? We are reading *this* paper

From a single SIGMOD paper

- **In this paper**, we attempt to approximate..
- Thus, **in this paper**, we explore how to use..
- **In this paper**, our focus is on indexing large collections..
- **In this paper**, we seek to approximate and index..
- Thus, **in this paper**, we explore how to use the..
- The indexing proposed **in this paper** belongs to the class of..
- Figure 1 summarizes all the symbols used **in this paper**…
- **In this paper**, we use Euclidean distance..
- The results to be presented **in this paper** do not..
- A key result to be proven later **in this paper** is that the..
- **In this paper**, we adopt the Euclidean distance function..

Use *all* the Space Available



Suppose we happen to have two nearly identical instances with the same class label in the training dataset. Furthermore, suppose they both happen to be useful

3 CONCLUSIONS AND FUTURE WORK

We have introduced the first exact motif search algorithm which is significantly faster than brute force search. We have further demonstrated the utility of motif discovery on a variety of data mining tasks.

to allow the exploration of truly massive datasets.

ACKNOWLEDGEMENTS: We would like to thank all the donors of datasets. We particularly thank Candice Stafford and Gregory P. Walker of the Entomological Dept. of UCR for their assistance with interpreting the Beet leafhopper data.

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Some reviewer is going to look at this empty space and say..

They could have had an additional experiment

They could have had more discussion of related work

They could have referenced more of my papers

etc

The best way to write a great 9 page paper, is to write a good 12 or 13 page paper and carefully pare it down.

Avoid Weak Language I

Compare

..with a dynamic series, it might fail to give accurate results.

With..

..with a dynamic series, it has been shown by [7] *to give inaccurate results.* (give a concrete reference)

Or..

..with a dynamic series, it will give inaccurate results, as we show in Section 7. (show me numbers)

Use the Active Voice

It can be seen that…

"seen" by whom?

Experiments were conducted…

The data was collected by us.

We can see that…

We conducted experiments...

Take responsibility

We collected the data.

Active voice is often shorter

William Strunk, Jr

The active voice is usually more direct and vigorous than the passive

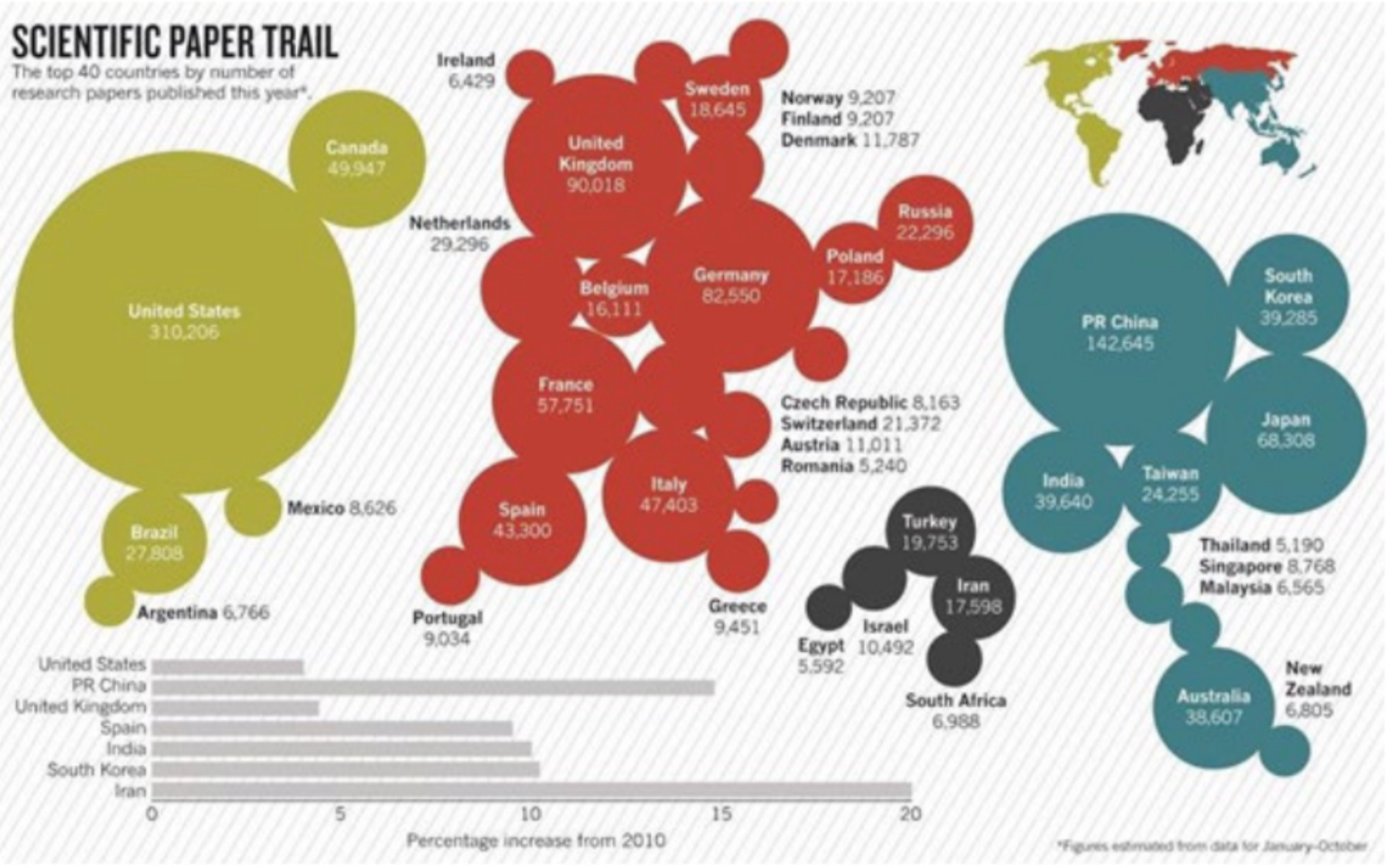
The most Common Problems with Figures

1. Too many patterns on bars
2. Use of both different symbols and different lines
3. Too many shades of gray on bars
4. Lines too thin (or thick)
5. Use of three-dimensional bars for only two variables
6. Lettering too small and font difficult to read
7. Symbols too small or difficult to distinguish
8. Redundant title printed on graph
9. Use of gray symbols or lines
10. Key outside the graph
11. Unnecessary numbers in the axis
12. Multiple colors map to the same shade of gray
13. Unnecessary shading in background
14. Using bitmap graphics (instead of vector graphics)
15. General carelessness

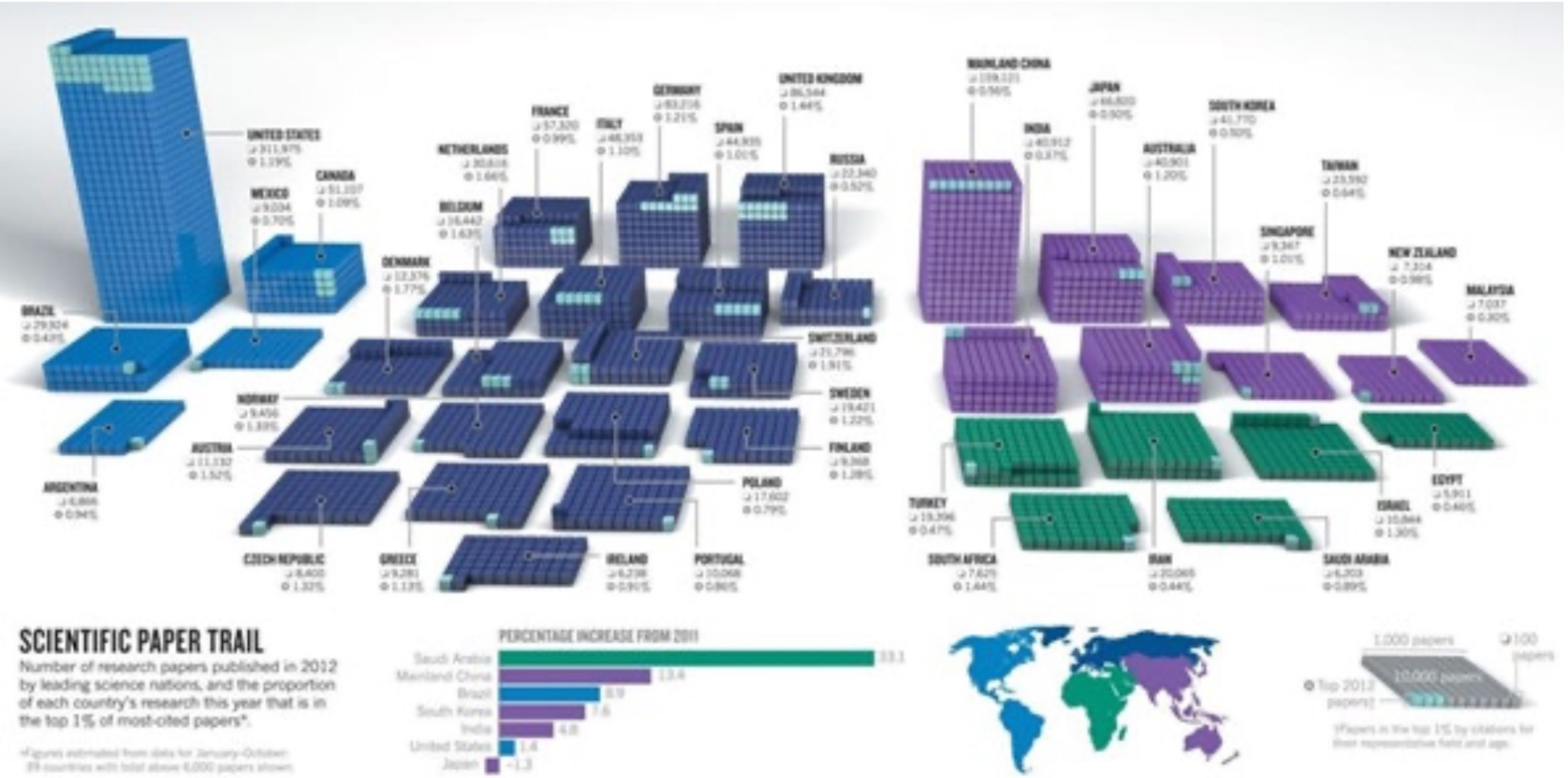
Eileen K Schofield: Quality of Graphs in Scientific Journals: An Exploratory Study. Science Editor, 25 (2), 39-41

Eamonn Keogh: *My Pet Peeves*

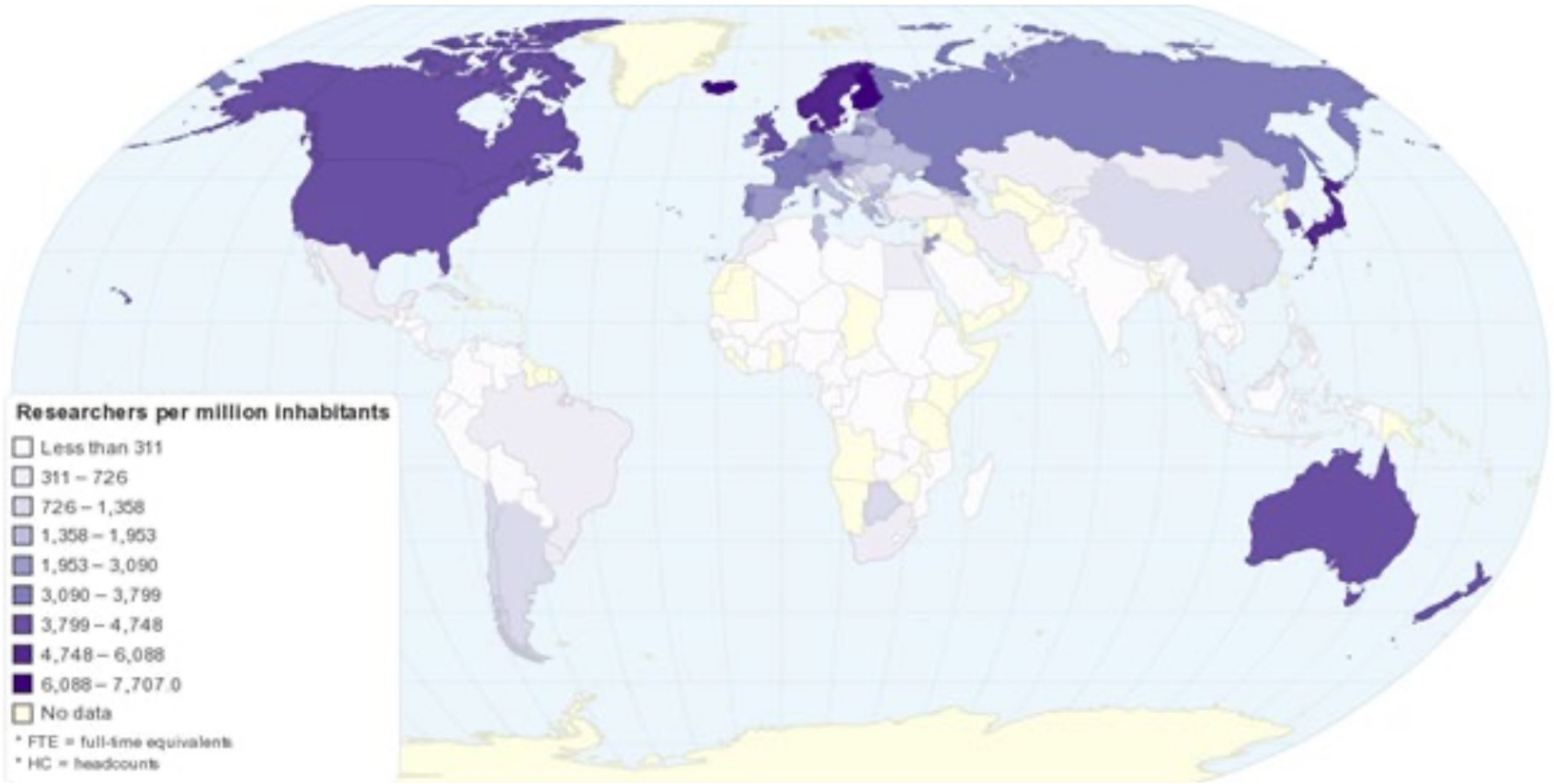

Novelty
Future
Joining of wholes
Reflecting
Formation of a whole
Interacting
Connection of parts
Doing
Gathering of parts
Researching & absorbing
Wisdom
Knowledge
Information
Data
Context
Understanding
http://lurnq.com
Past
Experience



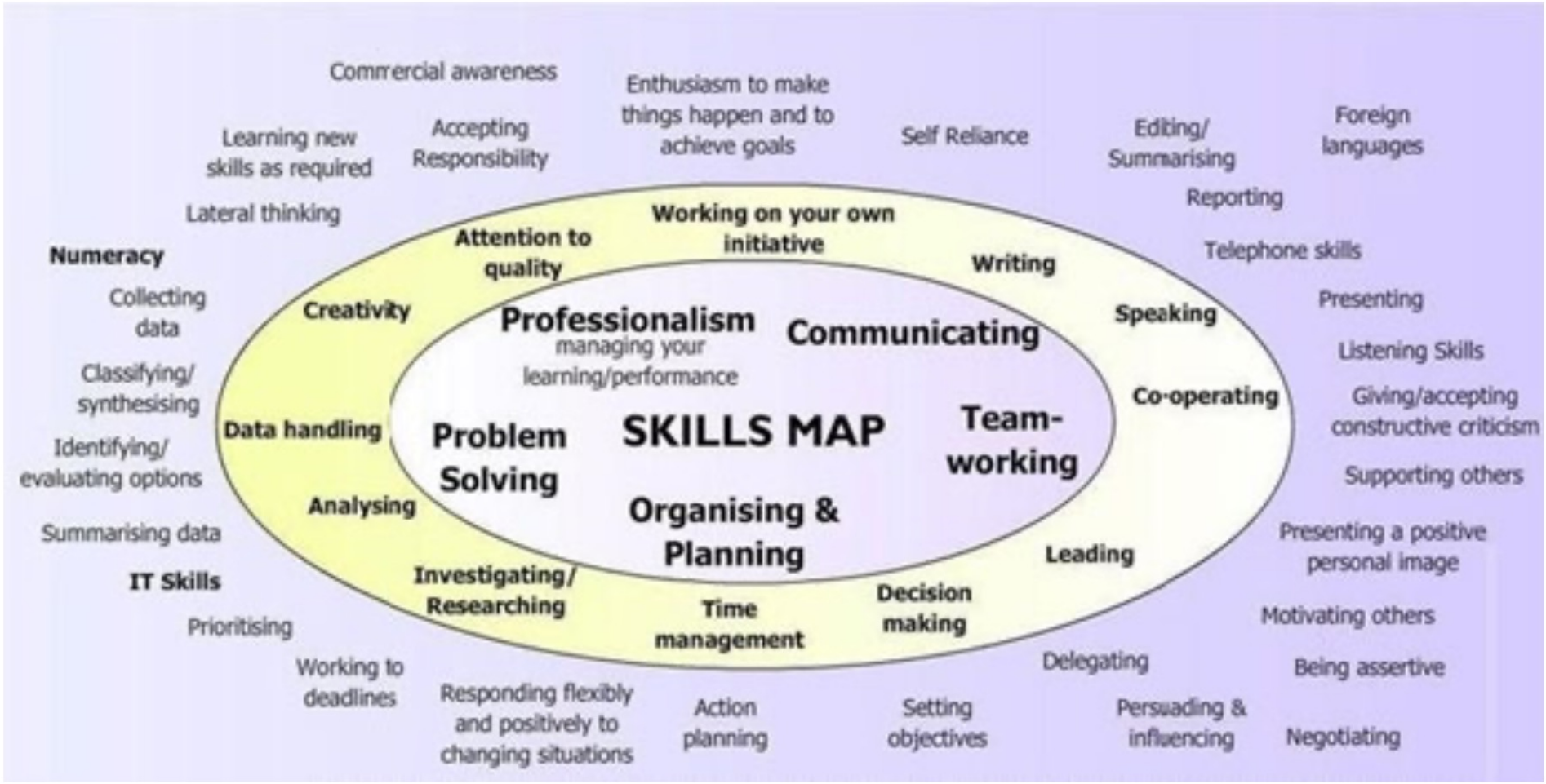
شكل ٥ توضيح لأعلى أربعين دولة في عدد الأبحاث العلمية لهذا العام (Source: Web of Science. Image by: Thomson Reuters)



شكل ٦ توضيح لعدد أوراق البحث العلمي المنشورة في عام ٢٠١٢(Source: Thomson Reuters/Essential Science Indicators)



شكل ٧ يوضح عدد الباحثين في كل مليون من سكان كل دولة (Source: ChartsBin.com)



شكل ٢ خريطة المهارات التي يجب أن يكتسبها الباحث (Source: www.kent.ac.uk/careers)

كن صبوًرا:

لا تُحبَط:

حافظ على سلامة ما توصلت إليه من نتائج:

استمتع بالتجربة:

«إنما العلم بالتعلُّم، وإنما الحلم بالتحلُّم، وإنما الصبر بالتصبُّر»
-الرسول الكريم صلى الله عليه وسلم