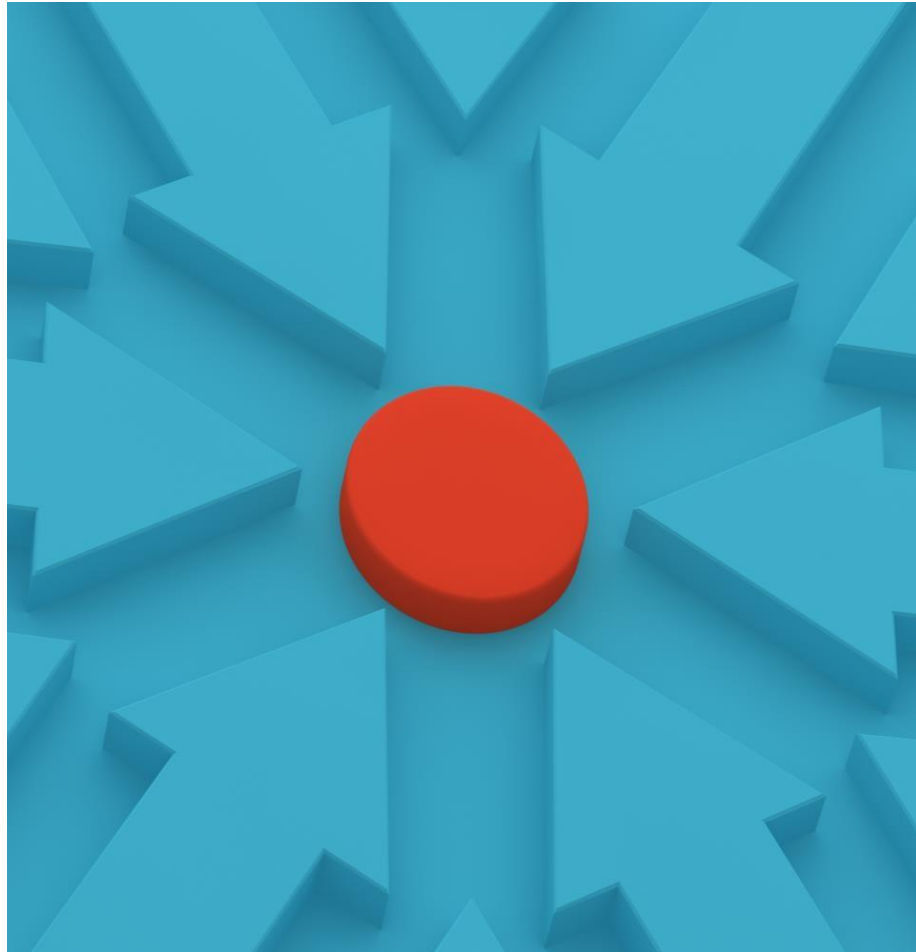


# **Lecture 1: Research & Papers**

# Instructors



- Carine Pierrette Mukamakuza/
- Kwan Lee
- Dabo

## TAs:

- Aisha

## Communication:

- Via Piazza/ Via WhatsApp
- Literature list @Canvas

# Research

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- This course is about **research** methods. Let us first define this important term.

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## Definition | Research

**Research** is a detailed study of subject to create new **generalizable** knowledge. Research can be applied to learn new **information**, create new **products** or develop new **solutions** to a given problem.

- **Example.** Consider the case of a broken window...



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- **Example.** Consider the case of a broken window...

If we perform a detailed study to determine who broke the window, we are not conducting research (but rather a detective investigation).



# Research

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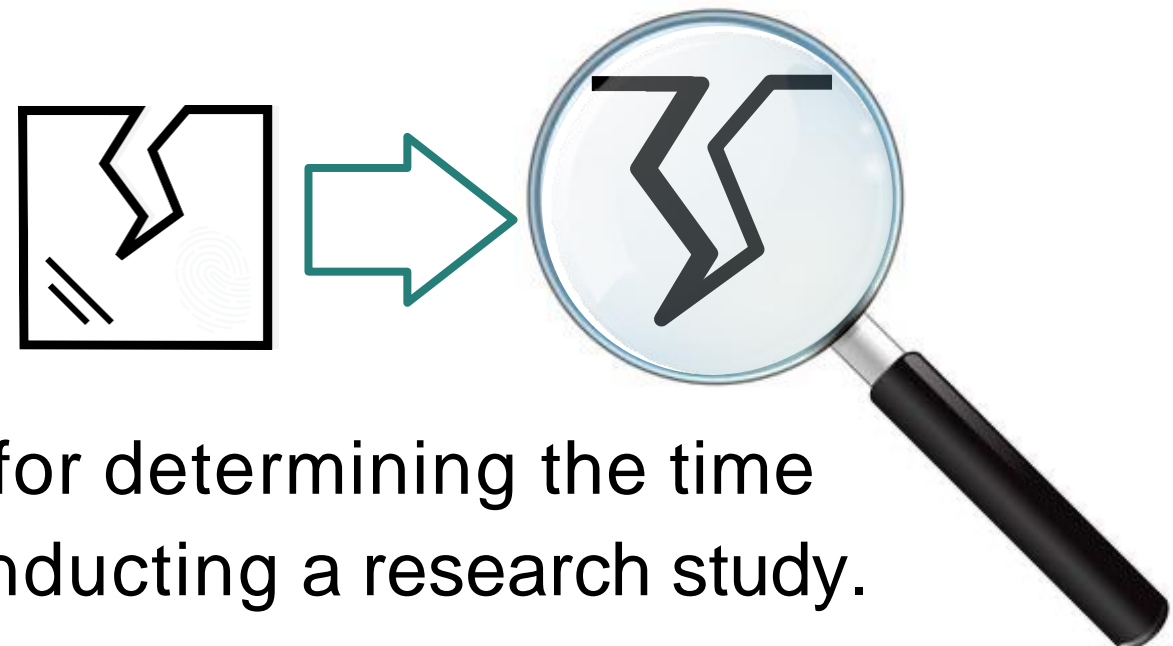
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- **Example.** Consider the case of a broken window...

In contrast, if we develop a new computational model to analyze

microscopic images of the crack for determining the time when it first appeared, we are conducting a research study.



# Scientific research

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- Let us now discuss the distinction between **scientific** research and other forms of research.
- Below is the flowchart of a scientific research study

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Collect  
observations



Formulate  
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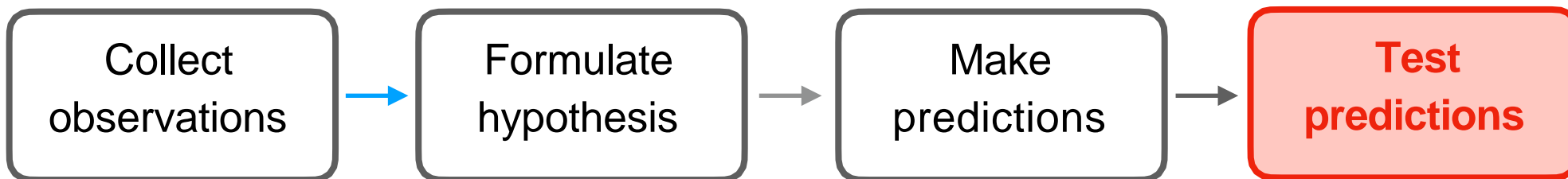


Make  
predictions

# Scientific research

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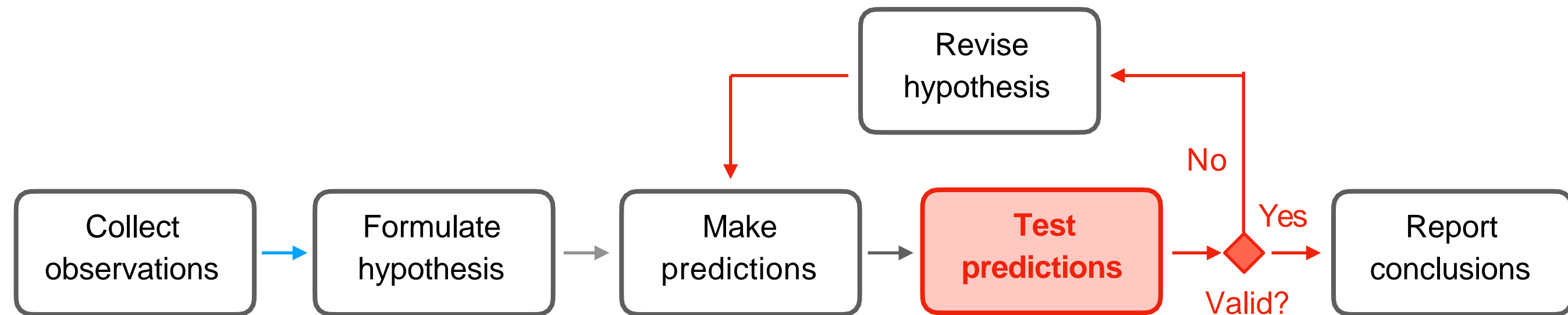
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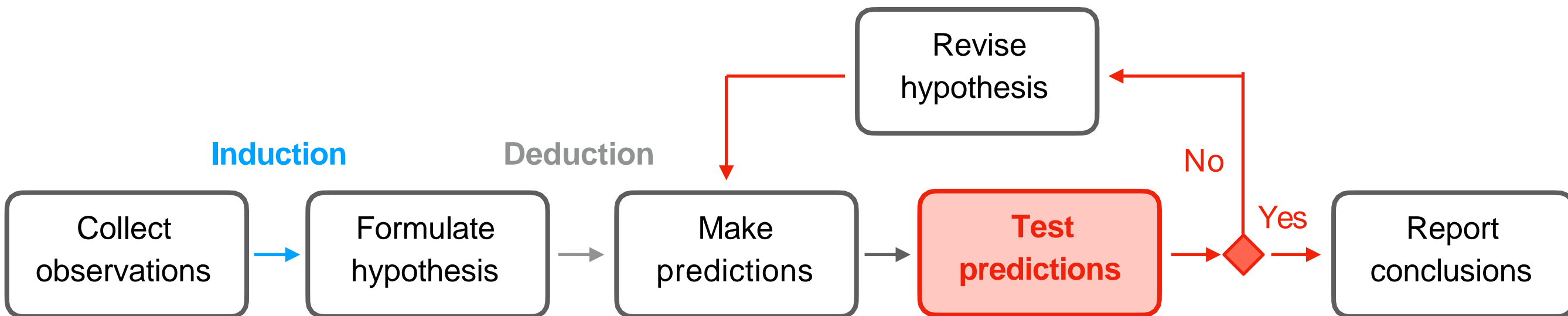
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In the inductive–deductive approach, **induction** is first used to infer explanations (the hypotheses) from observations. Then, deduction is applied to propose predictions from these explanations. Finally, **critical tests are conducted to check predictions**. The process is repeated until reaching new generalizable conclusions

# Scientific research

---

- The previous flowchart is the basis of the method of **scientific research**

## Definition | Scientific method

The scientific (inductive–deductive) method consists of three steps:

- making hypotheses based on observations (**induction**);
- deriving predictions from these hypotheses (**deduction**);
- validating the predictions (**critical testing**).

This process is iterated until reaching generalizable knowledge.

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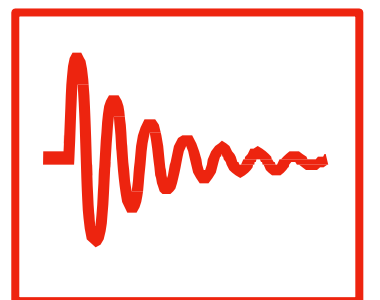
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- **Note.** The critical test may be an **observation** (the passive study of the evolution of a system) and an **experiment** (the active study of the response of a system)...



# Activity: 15 mn

## Instructions:

1. Form Groups:
2. Join a group with your peers for discussion (7 mn)
3. Identify the type of activity your group is working on from the following options:
  - Revising Hypotheses Based on Results
  - Identifying Patterns in Data
  - Hypothesis Formation
  - From Deduction to Prediction
4. Discuss the chosen activity in detail, including its purpose, methodology, and relevance to AI and data analysis.
5. Share Insights\_ key discussion points concisely(5mn)



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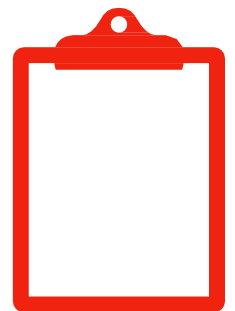
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- **Note (cont'd).** The critical test may also be **interview** (the interactive questioning of a subject) or it may be a **survey** (a non-interactive questioning of a subject).



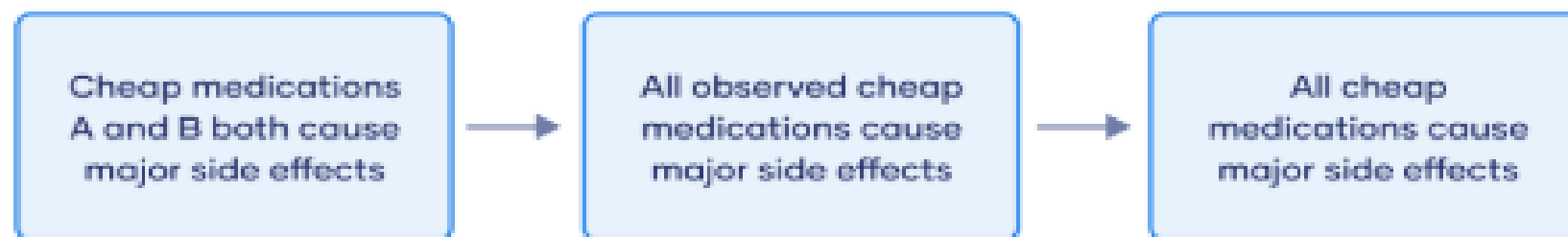


# Inductive vs Deductive

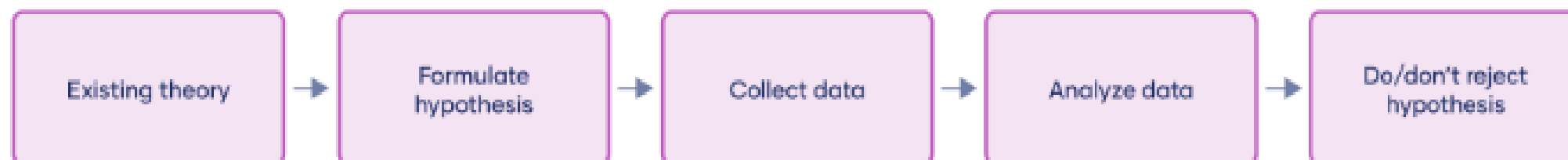
## Inductive reasoning



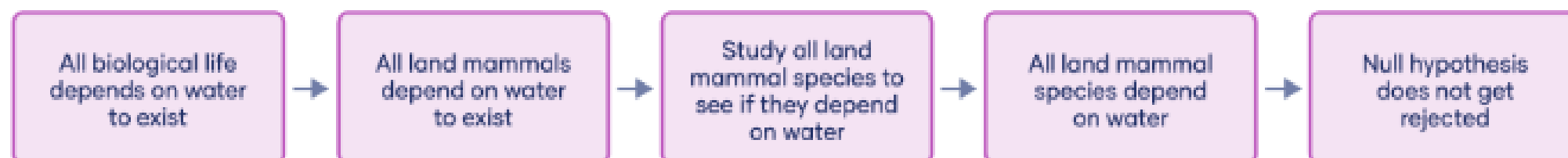
### Example



## Deductive reasoning



### Example



# Scientific hypothesis

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- **Important.** Not all proposed explanations qualify as acceptable scientific hypotheses.

## Definition | Scientific hypothesis

A **hypothesis** is a proposed explanation (an educated guess) for a observation. For this explanation to be a **scientific hypothesis**, it must be **falsifiable**, meaning that one should be able to find evidence that would disprove it.

- **Example.** Consider the following two hypotheses to explain the inefficiency of a given data processing task:

*Data loading accounts for more than half of the time for processing the data*

*There is an undetectable bottleneck in processing the data*

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- **Example.** Consider the following two hypotheses to explain the inefficiency of a given data processing task:

*Data loading accounts for more than half of the time for processing the data* ✓

*There is an undetectable bottleneck in processing the data* ✗

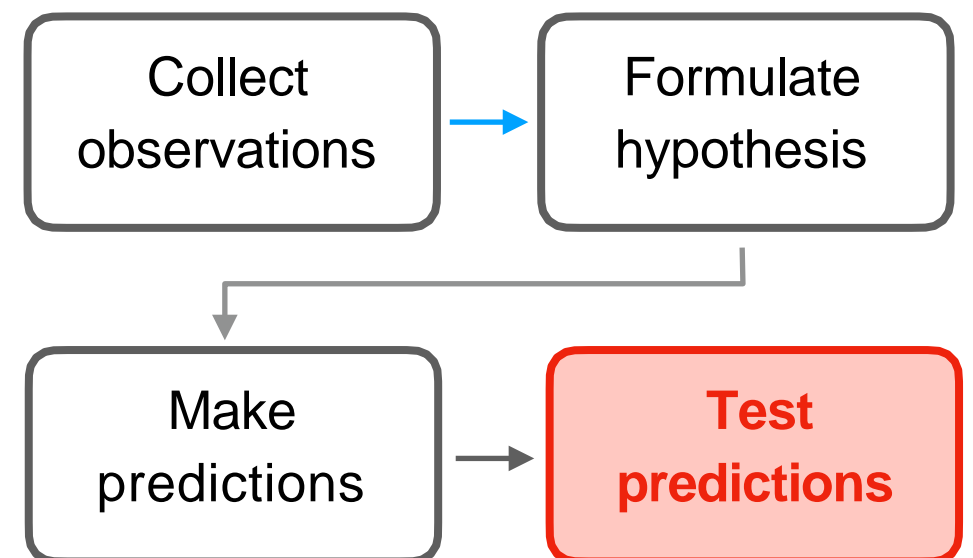
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- **Question.** Consider a research topic of interest to you and an interesting observation you made. Can you formulate a scientific falsifiable hypothesis for this observation? Then, try to formulate a non-falsifiable one.

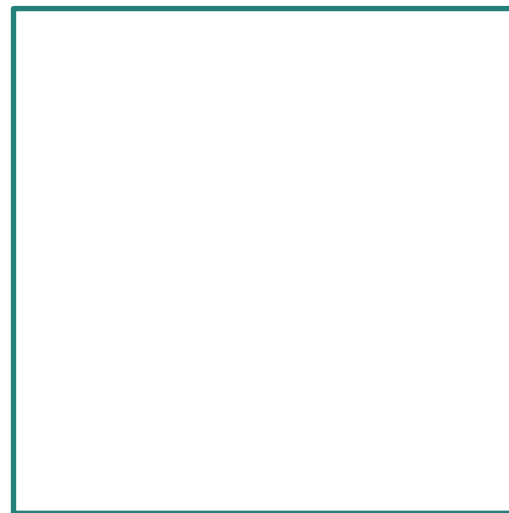


# Basic and applied research

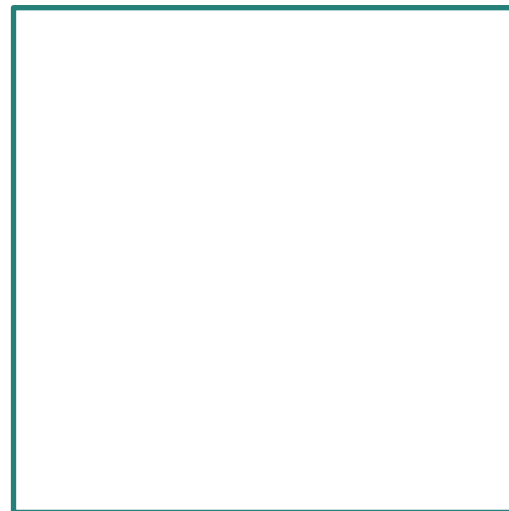
- Let us now discuss the relation and distinction between basic research and applied research

Quest for fundamental understanding

High



Low



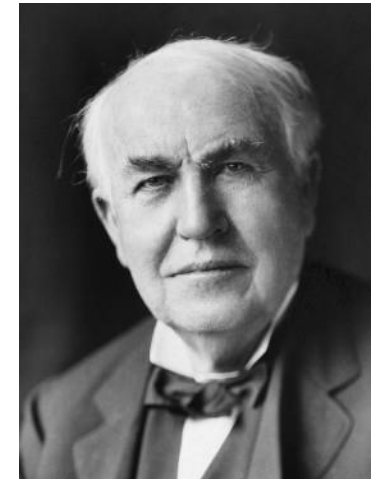
Low

High

Consideration of practical use



Niels Bohr



Thomas Edison



Louis Pasteur



Dilettante/tinkerer

**Question.** Can you place these four individuals in their respective box?

# Basic and applied research

- Let us now discuss the relation and distinction between basic research and applied research

Quest for fundamental understanding

High



Niels Bohr

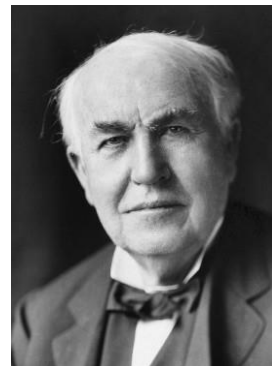


Louis Pasteur

Low



Dilettante/tinkerer



Thomas Edison

Low

High

Consideration of practical use

**Answer.** Niels Bohr contributed to understanding the structure of atoms, leading to fundamental physics discovery. Thomas Edison developed the first light bulb by trial-and-error search (now called the Edisonian approach). Louis Pasteur discovered the fundamental principles of immunization and developed anti-rabies vaccination. A dilettante or tinkerer does not seek generalizable knowledge.

Tinkerer: one who likes modifying objects without understanding  
Dilettante: one who cultivates interest in a topic without depth

# Basic and applied research

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- **Question.** Here are examples of research topics from the web. Which ones belong to **Bohr's** or **Edison's** quadrant?

*Investigating the Impact of Social Media on Teen Mental Health*

**Quadrant: Bohr's quadrant**

*Reasoning: While it explores a current issue, the research focuses more on understanding a psychological phenomenon than applying it to a solution.*

*Developing a Mobile App to Track Daily Water Intake*

**Quadrant: Edison's quadrant**

*Reasoning: This is applied research aimed at solving a practical problem helping people stay hydrated with technology.*

*Exploring the Relationship Between Sleep Patterns and Academic Performance in College Students*

**Quadrant: Bohr's quadrant**

*Reasoning: The goal is to understand a relationship rather than solve an immediate problem, focusing on scientific inquiry.*

*Creating a Smartwatch App for Fitness Tracking*

**Quadrant: Edison's quadrant**

*Reasoning: This research focuses on developing a product for practical use in fitness, a direct application of technology.*

- **Question.** How would you complement these topics so that they fit into Pasteur's quadrant?



# Scientific papers

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- One of the primary outputs of scientific research are **scientific papers** to report a new piece of information, a new product., or a new solution.

## Definition | Scientific paper

A scientific paper is a document that describes a research study and reports its generalizable conclusion. Typical scientific papers are a discussion of an unknown phenomenon, a presentation of a discovery, an addition to a previous research study, or a comparative study between different approaches.

- **Question 1.** What is the difference between a paper, a manuscript, and an article?



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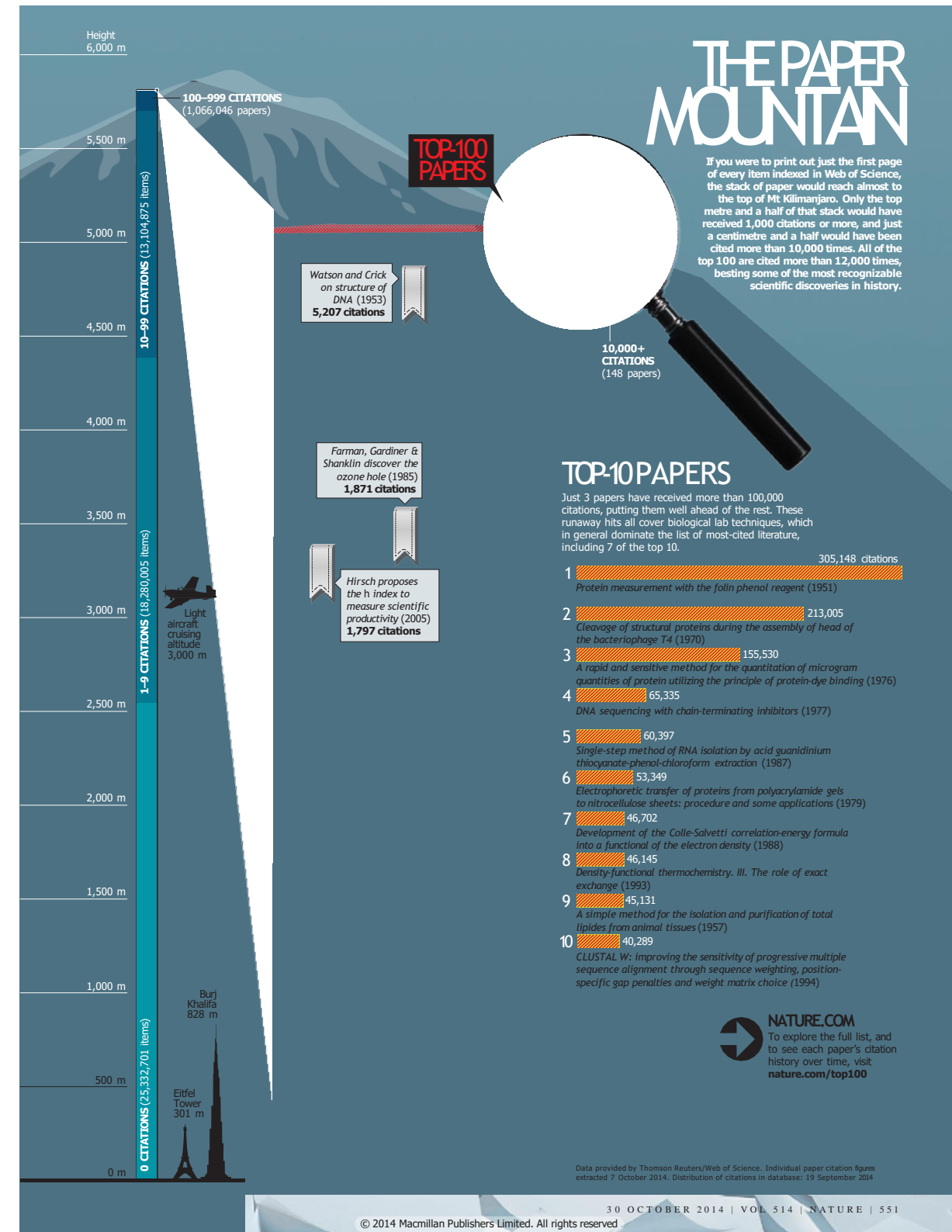
- **Question 1.** What is the difference between a paper, a manuscript, and an article?
- **Answer.** An article is a published paper while a manuscript is a paper that has not yet been published.

# Scientific papers

- ▶ Here is a visual illustration of the amount of scientific articles in the history of humanity.
- ▶ **Questions.** What does this paper mountain represent?

How are the papers ranked? Why are they ranked that way?

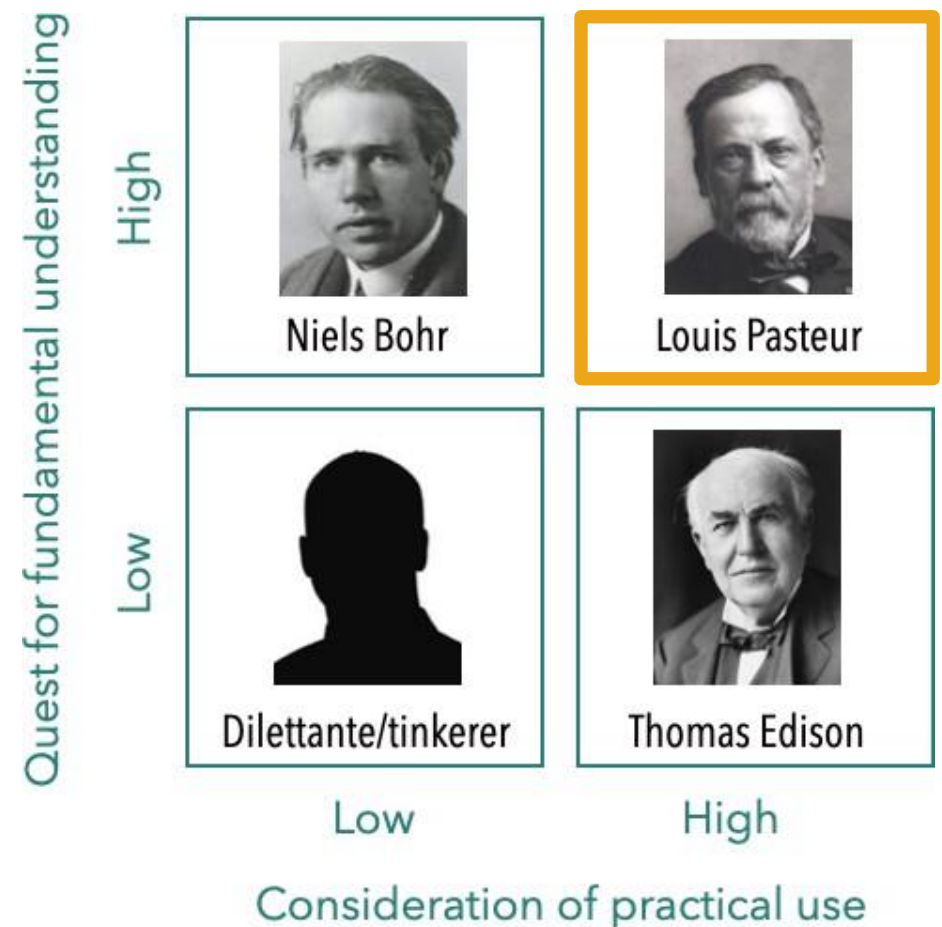
Do you agree with the ranking? How should it be modified?



# Summary

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- **Research** targets **generalizable** knowledge.
- **Scientific research** typically consists of the three steps, which are **induction**, **deduction**, and **critical testing**.
- A scientific hypothesis must be **falsifiable**.
- **Pasteur's quadrant** refers to the intersection between basic research and applied research.
- A **manuscript** is an unpublished paper while an **article** is a paper that has already been published in a journal.



# Addendum/erratum

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- P. 11: Definitions for dilettante and tinkerer have been added
- P. 15: Summary slide has been added.