

## PHYS 395 Research Methods - Lecture 1

# Scientific research, its quality, and characteristics

Sergiy Bubin

*Department of Physics  
Nazarbayev University*

## A few definitions (from dictionary)

### **Science** is

The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment

### **Scientific Research** is

The systematic investigation of scientific theories and hypotheses.

### **Hypothesis** is

a single assertion, a proposed explanation of something based on available knowledge, for something yet to be explained.

# The scientific method

The scientific method is an *empirical* method of acquiring knowledge and constructing an accurate depiction of the world around us

Main components:

- Formulation of principal questions
- Careful and systematic observations
- Rigorous skepticism about what is observed
- Test of the hypotheses via experiments
- Analysis
- Refinement of the hypotheses

# Key properties of the scientific method

- No prejudice
- Hypothesis must be falsifiable (disprovable)
- Results must be reproducible

# Types of research

- Basic (pure, fundamental) research
- Applied research
- Theoretical research
- Computational research
- Experimental (observational) research
- Clinical research
- Problem solving research
- Quantitative research
- Qualitative research

## Some characteristics of good research

- Conceptual clarity (purpose is clearly identified)
- Resonates with interest in the community
- Contributes new knowledge in the field
- Research questions must be feasible
- Testable
- Reproducible (in principle)
- Can be performed within given amount of time, human resources, energy, and money
- Has a specific plan or procedure
- Does not violate ethical standards

## Some characteristics of bad research

- Looking for something when it simply is not to be found.
- Falsified data to prove a point
- Misrepresenting information and misleading participants
- Plagiarizing other people's work.
- Other ethical issues (e.g. bad impact on the environment, animal cruelty)

Why should the society even to care?

## Elements of good research proposals

- Relevance
- Timeliness
- Application of sound methods
- Done by competent executors
- A comprehensive review of available knowledge and its limits (with references to literature sources)
- Evidenced-based conclusions
- Consideration of limitations, making them explicit and avoiding bias
- Use of high quality data sets
- Usefulness of the research products
- Impact on the expert community or society overall
- Limitations (and shortcomings) are frankly revealed

# Assessing the quality of proposed and executed research

There exist various mechanisms and quality markers

- Independent external peer review processes
- Quality perception surveys
- Periodic evaluation of performance (e.g. via annual reports)
- Number of indexed articles and other works published
- Number of patents obtained
- Number of products/devices developed