

# **Methodology of scientific researches**

Khamzina B.E.  
Doctor of pedagogical sciences,  
associate professor

# **BASES OF SCIENTIFIC RESEARCH METHODOLOGY**



## **LECTURE 1**

**I WHAT IS RESEARCH?**

**II. RESEARCH**

**METHODS AND**

**RESEARCH**

**METHODOLOGY**

**LECTURE 2 TYPES OF**

**RESEARCH**

How to do  
scientific  
research?

How to publish  
results?  
Is it important?

How to plan  
my thesis?

How are  
research results  
assessed?

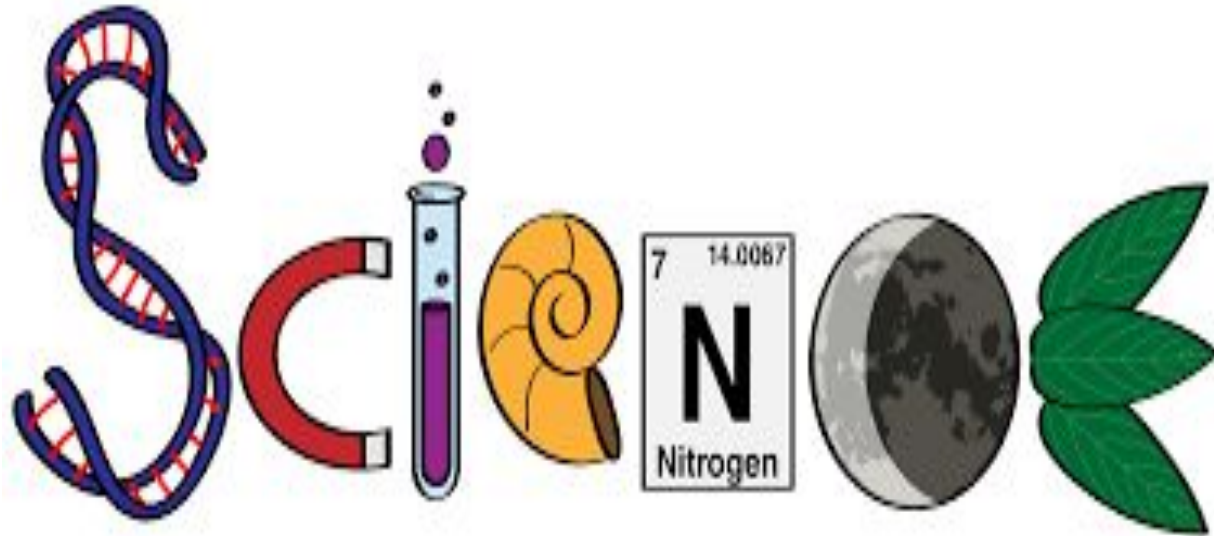
How to plan and  
manage a  
research project?



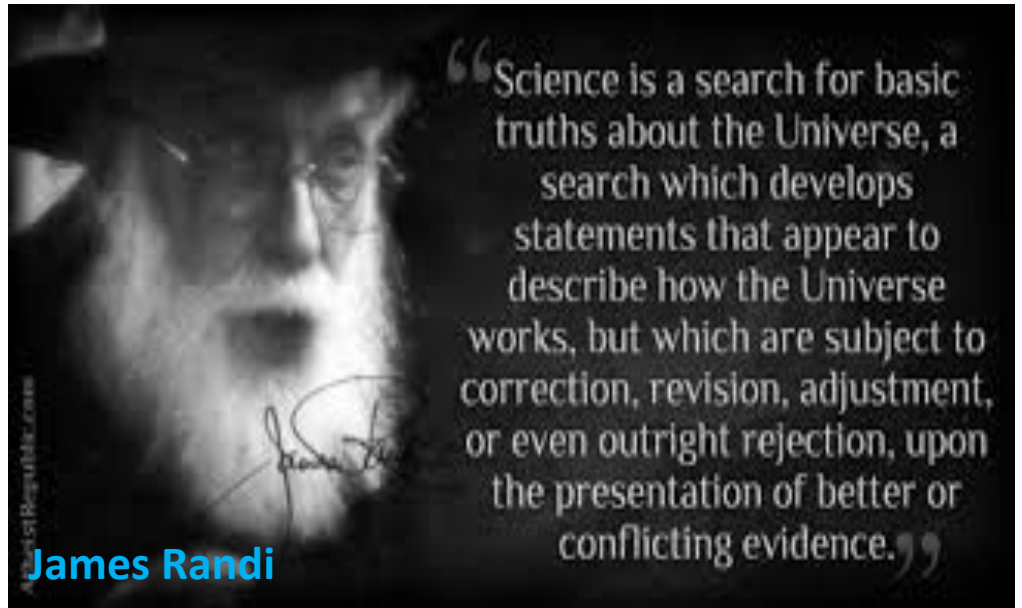
# BASE CONCEPTS

SCIENCE, TECHNOLOGY, ENGINEERING,  
INNOVATION, SCIENTIFIC THEORY,  
SCIENTIFIC LAW, HYPOTHESIS, THESIS,  
PARADIGM, RESEARCH,

# What is Science?



SCIENCE  
— is the —  
POETRY  
— of —  
REALITY



**Science is not only a disciple of reason but, also, one of romance and passion.**

-Stephen Hawking

Inspirational Quotes Club





## SCIENCE:

1. The **systematic observation** of natural events and conditions in order to **discover facts** about them and to **formulate laws and principles** based on these facts.
2. The organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation.
3. Any specific branch of this general body of knowledge, such as biology, physics, geology, or astronomy.

*Academic Press Dictionary of Science & Technology*

Science is an intellectual activity carried on by humans that is designed to **discover information** about the natural world in which humans live and to discover the ways in which this information can be **organized into meaningful patterns**.

A primary aim of science is to **collect facts** (data). An ultimate purpose of science is to **discern the order** that exists between and amongst the various facts.

*Sheldon Gottlieb - [http://www.theharbinger.org/articles/rel\\_sci/gottlieb.html](http://www.theharbinger.org/articles/rel_sci/gottlieb.html)*

*<http://www.gly.uga.edu/railsback/1122science3.html>*



## TECHNOLOGY:

Technology is the process by which humans **modify nature** to meet their needs and wants.

"...the know-how and creative processes that may assist people to **utilise tools**, resources and systems to **solve problems** and to **enhance control** over the natural and made environment in an endeavour to **improve the human condition**." (UNESCO, 1985).

Often **Science and Technology** appear together

→ **S&T**

referring to advanced technology  
based on new scientific principles

## ENGINEERING:

“The **creative application** of scientific principles  
to **design or develop** structures, machines, apparatus, or manufacturing  
processes, or works utilizing them singly or in combination;  
or to **construct or operate** the same with full cognizance of their design;  
or to **forecast** their behavior under specific operating conditions;  
all as respects an intended function, economics of operation and safety to life  
and property.”

*American Engineers' Council for Professional Development*

**Science** aims to **understand the "why" and "how"** of nature.

**Engineering** seeks to **shape** the natural world to meet human needs  
and wants.

*Scientists **study** the world as it is; engineers **create** the world that has  
never been.*

*Theodore von Kármán*

# Innovation

The introduction of something **new**, a new way of doing something, the **successful exploitation** of new ideas.

**Invention** - an idea made manifest

... the first occurrence of an idea for a new product or process

**Innovation** - ideas applied successfully

... the first attempt to carry it out into practice

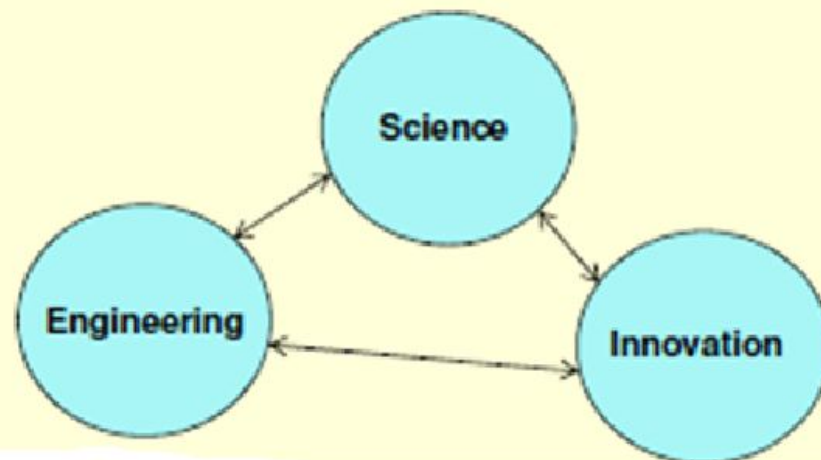
- **Incremental innovation** - where something is adapted or modified.
- **Radical innovation** - which involves completely new ideas.



## DISCUSSION:

Which relationship?

Do all scientists invent something?



## Science vs. technology ? One view

	Science	Technology
Object	unchangeable	changeable
Principle of motion	inside	outside
End	knowing the general	knowing the concrete
Activity	theoria: end in itself	poiesis: end in something else
Method	abstraction	modeling concrete (complex)
Process	conceptualizing	optimizing
Innovation form	discovery	invention
Type of result	law-like statements	rule-like statements
Time perspective	long-term	short-term



## Science – some characteristics

- **Science is empirical.** Science relies on experience more than authority, common sense, or logic.
- **Science is objective.** Objectivity means that same conclusion should be arrived if same observation is made.
- **Science is self-correcting.** Because science is empirical, new evidences may contradict the old ones.
- **Science is progressive.** Because science is empirical and self-correcting, it is also progressive.
- **Science is tentative.** Science never claims to have the whole truth. New information may make current knowledge obsolete.
- **Science is parsimonious.** Use the simplest explanation to account for a phenomenon.

## Evolution of science ...

**Traditional view** - **linear and cumulative** (follows a direct path from past to present, adding at each point to the achievements of earlier generations)

### Kuhn's view:

- Scientific development is not smooth and linear; instead it is **episodic**—that is, different kinds of science occur at different times.
- The most significant episodes in the development of a science are **normal science** and **revolutionary science**. *It is also cyclical with these episodes repeating themselves.*
- Nor is it cumulative, since revolutionary science typically discards some of the achievements of earlier scientists.
- Science does not itself aim at some grand goal such as the Truth; rather individual scientists seek to solve the puzzles they happen to be faced with.
- There is no logic of science or fixed scientific method. Instead scientists make discoveries thanks to their training with exemplary solutions to past puzzles



# Scientific theory, scientific law

## Theory

- the *explanation* or a model for a phenomenon
- a conceptual framework that *explains* existing observations and *predicts* new ones
- a logical, time tested explanation for events that occur in nature.

Theories not only describe *why* or *how* the phenomenon occurred but also *guide* the way for further research.

A real Scientific Theory tells you what observations are necessary to **falsify** it.

Theories can really never be completely proven, only disproven. When new evidence comes along, we must modify our theory or at times even get rid of it and start over again.

# Hypothesis

## Hypothesis:

This is an educated guess based upon observation. It is a rational explanation of a single event or phenomenon based upon what is observed, *but which has not been proved*.

**A hypothesis is basically a(n educated) guess.**

It is a possible answer to the problem or question.

## A hypothesis is testable and falsifiable

A hypothesis is an explanation for a phenomenon which can be tested in some way which ideally either proves or disproves the hypothesis. For the duration of testing, the hypothesis is taken to be true, and the **goal of the researcher is to rigorously test the terms of the hypothesis.**

When a hypothesis passes the test it is adopted as a theory (or *thesis*) as it correctly explains a range of phenomena but it *can*, at any time, be falsified by new experimental evidence.

# Thesis

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## Thesis:

A thesis statement declares what you believe and what you intend to prove.

"a position or proposition that a person (as a candidate for scholastic honors) advances and offers to maintain by argument."  
[Webster's 7th New Collegiate Dictionary].

A **defense** presents evidence for a thesis.



# Paradigm


## Paradigm:

"a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated; *broadly* : a philosophical or theoretical framework of any kind.

Merriam-Webster Online dictionary

A paradigm is a "**excellent example**", a model to which others aspire.

Usually scientists seek to match their work to the paradigm in a way that depends on their seeing similarities between their work and the paradigm



"Followers"

**Paradigm Shift** is when a significant change happens  
or scientific revolution

... when scientists encounter anomalies which cannot be explained by the universally accepted paradigm within which scientific progress has thereto been made.

# Discipline

A particular branch of scientific knowledge.

A *discipline* has six basic characteristics:

- (1) Focus of study
- (2) Paradigm
- (3) Reference disciplines
- (4) Principles and practices
- (5) Research agenda
- (6) Education
- (7) Professionalism

*Liles et al. (1995),*

**Discussion:** *Is Robotics a discipline?  
And Collaborative Networks?  
And Cloud Computing?*

## The emergence of a new discipline

When enough significant **anomalies** have accrued against a current paradigm, the scientific discipline is thrown into a state of **crisis**, according to Kuhn.

During this crisis, new ideas, perhaps ones previously discarded, are tried.

Eventually a **new paradigm** is formed, which gains its own new followers, and an intellectual "**battle**" takes place between the followers of the new paradigm and the hold-outs of the old paradigm.

The new paradigm may lead to a new discipline.

[www.computer.org/portal/site/computer/menuitem.5d61c1d591162e4b0ef1bd108bcd45f3/index.jsp?&pName=computer\\_level1\\_article&TheCat=1015&path=computer/homepage/1205&file=profession.xml&xsl=article.xsl&jsessionId=JvyLpgTKQzWNJqGWnpKNh6QL9JBVk1dhVQyt8pWsXTJTGjjd9CSG!-1582182879](http://www.computer.org/portal/site/computer/menuitem.5d61c1d591162e4b0ef1bd108bcd45f3/index.jsp?&pName=computer_level1_article&TheCat=1015&path=computer/homepage/1205&file=profession.xml&xsl=article.xsl&jsessionId=JvyLpgTKQzWNJqGWnpKNh6QL9JBVk1dhVQyt8pWsXTJTGjjd9CSG!-1582182879)





# Research

**Research** is the **systematic process of collecting and analyzing** information to **increase our understanding** of a phenomenon under study.

- a. The systematic investigation into and study of materials, sources, etc, in order to establish facts and reach new conclusions.
- b. An endeavour to discover new or collate old facts etc by the scientific study of a subject or by a course of critical investigation.

*[Oxford Concise Dictionary]*

Research encompasses activities that increase the sum of human knowledge.

*[OECD Definition]*

The word **research** is composed of two syllables, **re** and **search**.

The dictionary defines the former as a prefix meaning again, anew or over again and the latter as a verb meaning to examine closely and carefully, to test and try, or to probe.

Together they form a noun describing a **careful, systematic, patient study and investigation** in some field of knowledge, undertaken to establish facts or principles.

*[Grinnel, 1993]*

## Research ...

The **systematic** process of collecting and analyzing information (data) in order to discover new knowledge or expand and verify the existing one (e.g. theory - law)

The research process **must** :

1. Be undertaken within a framework of a set of philosophies.
2. Use procedures, methods and techniques that have been tested for their validity and reliability.
3. Be designed to be unbiased and objective.

**Subjectivity**: an integral part of your way of thinking that is conditioned by your educational background, discipline, philosophy, experience and skills.

**Bias**: a deliberate attempt to either conceal or highlight something.



# Research and Development – R&D

Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to **increase the stock of knowledge**, including knowledge of man, culture and society, and **the use of this stock of knowledge to devise new applications.**

*[OECD Definition]*

In the world of business, research and development is the phase in a product's life that might be considered the **product's 'conception'**:

- **research phase**: basic science must exist to support the product's viability, and if the science is lacking, it must be discovered.
- **development phase**: if the science exists, then turning it into a useful product.

# Research characteristics

To qualify as **research** the process must have the following **characteristics**:

- **Controlled** – in exploring causality in relation to two variables, the study must be set in a way to minimise the effects of other factors affecting the relationship.
- **Rigorous** – be scrupulous in ensuring that the procedures followed to find answers to questions are relevant, appropriate and justified.
- **Systematic** – the procedures adopted to undertake an investigation follow a certain logical sequence ... Different steps cannot be taken in a hazardous way.
- **Valid and verifiable** – whatever is concluded on the basis of the findings must be correct and can be verified by the researcher and others.
- **Empirical** – any conclusions drawn are based upon hard evidence gathered from information collected from real-life experiences or observations.
- **Critical** – critical scrutiny of the procedures used and the methods employed.



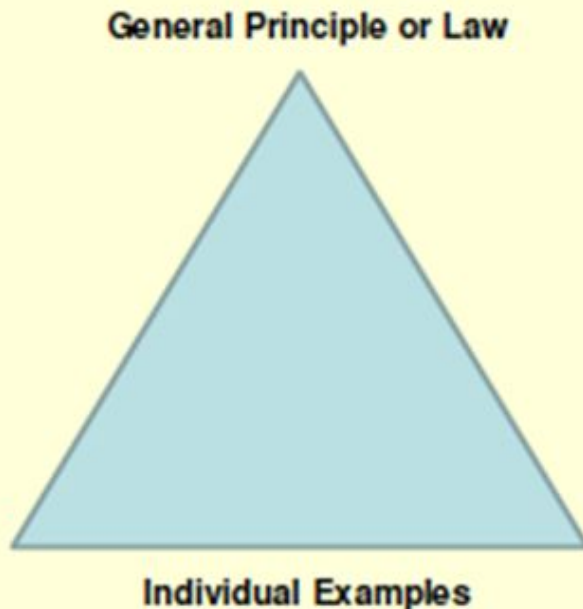
# Principles

## Deduction vs. Induction

### DEDUCTION

- Begins with a general principle and reasons to particulars (individual examples)
- Type of reasoning most commonly associated with geometric proofs

- ❑ Advantage: If all the terms are perfectly defined it produces absolute certainty
- ❑ Disadvantage: Difficult to find circumstances in which all terms and principles can be defined perfectly



### INDUCTION

- Begins with observation of individual examples and reasons to form general principles about their relationships
- Type of reasoning most commonly associated with experimentation

- ❑ Advantage: Relatively easy to do – just observe the world
- ❑ Disadvantage: Can never be absolutely certain one has observed ALL particulars

## **3. SCIENTIFIC RESEARCH**



## Brief history landmarks

### Aristotle



(384 BC - 322 BC)

Aristotle, more than any other thinker, determined the orientation and the content of Western intellectual history.

He was the author of a philosophical and scientific system that through the centuries became the support and vehicle for both medieval Christian and Islamic scholastic thought: until the end of the 17th century, Western culture was Aristotelian.

Aristotle and his contemporaries **believed that all problems could be solved by thinking about them.**

Sometimes this worked, other times it did not.

For example, Aristotle thought that heavy objects would fall faster than lighter ones.

What did Aristotle not do?

**He never tested his ideas!**

The world would have to wait almost 2000 years for that to happen.

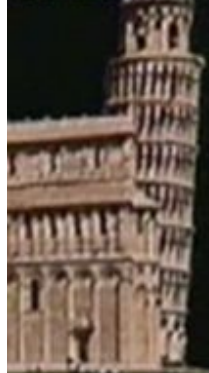
## Brief history landmarks ...

### Galileo Galilei



(1564-1642 AD)

### Galileo's Experiment



Objects of  
different weights  
will fall at  
the same speed



Often considered the first true scientist.

Why?

Because **he** actually **did the experiment** !

Aristotle thought that heavy objects fall faster than lighter ones.

So Galileo asked, "How much faster?"

He sent students up to the top of a building and had them drop a heavy ball and a lighter one off at the same time. He had other students waiting below to measure the difference in time between the two hitting the ground.

Much to everyone's surprise both balls hit the ground at about the same time!

This shows that it is much preferred to test your ideas rather than merely think about them.

.... Simulation is not enough either !



## Brief history landmarks ...

### Ibn al-Haytham

(Alhacen or Alhazen)



(965 - 1039 AD)

Perhaps not so known in the West ....

He is considered the **pioneer of the modern scientific method** and the originator of the experimental nature of physics and science  
... long before Galileo

He made significant improvements in optics, physical science, and the scientific method which influenced the development of science for over five hundred years after his death.

Ibn al-Haytham's work on optics is credited with contributing a new **emphasis on experiment**.

Example:

Ibn al-Haytham proved that light travels in straight lines using the scientific method.

## Types of research – *Viewpoint of application*

### ■ Pure, basic, or fundamental research

- Driven by the **scientist's curiosity** or interest in a scientific question.
- Involves development and testing theories and hypothesis that are intellectually challenging to the researcher but may or may not have practical application at the present time or in the future.
- ...Frequently involve very abstract and specialized concepts

### ■ Applied research

- Designed to **solve practical problems** of the real world, rather than to acquire knowledge for knowledge's sake.
- Often involves the use of some technology in the development of new processes or systems.
- Frequently linked to R&D

*What distinguishes applied research from engineering?*



## Types of research – *Viewpoint of application ...*

### Another classification:

- **Pure basic research** is experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than the advancement of knowledge.
- **Strategic basic research** is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems.
- **Applied research** is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.
- **Experimental development** is systematic work, using existing knowledge gained from research or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

# Types of research – *Viewpoint of objectives*

- **Descriptive research** Attempts to describe systematically a situation, problem, phenomenon, service, etc. E.g. Structure of a system, organization, etc.
- **Correlational research** To discover or establish the existence of a relationship / association / interdependence between two or more aspects of a situation. E.g. What is the relationship / impact / effect of <this> in <that>.
- **Explanatory research** Attempts to clarify or explain why and how there is a relationship between two aspects of a situation or phenomenon.
- **Exploratory research** When the objective is to explore an area where little is known or to investigate the possibility of launching a particular research study.

[Kumar, 2005]

## Another perspective:

**Descriptive** (of the significant aspects of the research domain)

**Explicative** (of the behavior of a phenomenon)

**Predictive** (of the future)

**Prescriptive** (involving, in addition to prediction, prescription and application of norms and processes)



# Types of research – *Viewpoint of inquiry mode* (Strategies of inquiry)

## ■ Quantitative strategies (or structure approach) ... to determine the **extent** of a problem, issue, or phenomenon

Survey research ... Studies samples

Experimental research ... To determine impacts or influences

## ■ Qualitative strategies (or unstructure approach) ... to explore the **nature** of a problem, issue, or phenomenon

Ethnography ... Studies an intact “cultural group” in a natural setting over a prolonged period of time

Grounded theory ... Derives a general, abstract theory of a process, action, or interaction grounded in the views of participants

Case studies ... Exploring in depth an event, activity, process or entity

Phenomenological research ... Trying to understand the meaning of a phenomenon as perceived by the actors that “lived it”

Narrative research ... Based on the analysis of stories / narratives

# Types of research – *Viewpoint of inquiry mode ...*

## ■ Mixed strategies

### Sequential mixed methods

- Elaborate on / or expand the findings of one method with another method

### Concurrent mixed methods

- Merges quantitative and qualitative data in order to reach a comprehensive analysis of the research problem

### Transformative mixed methods

- Uses a theoretical lens to determine topics of interest and the methods to apply

## **4. PRACTICAL ISSUES**



## You and your supervisor ?



## Relationship with supervisor

- Scientific & methodological guidance
- Suggestions and assessment
- Reassurance, support
- Polishing technical writing
- Resources, hosting project
- Contacts, social networking
- Facilitator to access scientific channels
- Experience
- *Mentor, friend, confidante, adviser and also a voice of reason*
- ...

**SUPERVISOR**



**STUDENT**

- Hard work, enthusiasm
- Labor resource (for projects, etc.)
- Generation of experimental results
- Contribution to publications
- Contribution to project proposals (at a later stage)
- ...

## Choosing a supervisor

*Before jumping into the unknown,  
remember that your supervisor will be your guide*

*... One of the most critical decisions ...*

- Is an expert in the area you selected ?
- Is internationally recognized in the area ?
- Is well connected in the international scientific arena ?
- Is willing and able to promote your work at conferences and the like?
- Is active (research, publications) ?
- Has previous supervision experience ?
- Is interested in the topic you selected ?
- Can provide research facilities ?
- Is willing to fight the *system* for you ?
- Will you be integrated in a group ?
- Do you want co-supervision?
  
- Personal chemistry ?





## How does a researcher work?



## Emotional factors

- ◆ Research is **hard**.
- ◆ All research involves **risk**.... If your project can't fail, it is development, not research.
- ◆ Along your career, you'll accumulate a lot of **failures**.  
... Even the (apparently) successful researchers accumulate (many) failures.
- ◆ Research always takes much, much **longer** than it initially seems.
- ◆ Crucial to success is making your research **part of your everyday life**.  
... think about your research in background mode all the time.
- ◆ You'll find that your **rate of progress** seems to vary a lot ... Sometimes no progress at all.  
At other times you get stuck and feel like you can't do anything for a long time.  
Setting your sights too high leads to paralysis.  
Work on a sub-problem to get back into the flow.  
It's hard to get started working in the morning, easy to keep going once you've started → Leave something easy or fun unfinished in the evening that you can start with in the morning.
- ◆ **Fear of failure** can make work hard and discourage.

*Based on MIT: [www.cs.indiana.edu/mit\\_research.how.to/section3.13.html](http://www.cs.indiana.edu/mit_research.how.to/section3.13.html)*

■ You are aiming a **Master**, not a Nobel prize (at this time) !



# How should you work?

## SOME HINTS FOR A PhD CANDIDATE:

- ◆ Work regularly ... It helps keeping things in mind.
- ◆ Allocate large blocks of time for research
  - ... Task switching takes time
  - ... Do something significant in each session
- ◆ Maintain a research notebook / journal of day-to-day thoughts.  
Read it periodically.
- ◆ Keep an updated task list ... and focus on accomplishing something each session.
- ◆ Periodically write a few pages (summaries, accomplishments, problems, speculations) on a subset of your work.

**A good practice:** send a 1-page summary, weekly, to your supervisor

- What you have achieved during the week  
(not the activities but rather the achievements)
- What you plan to do during next week.





- *Research* is a logical and systematic search for new and useful information on a particular topic.
- It is an investigation of finding solutions to scientific and social problems through objective and systematic analysis.
- It is a search for knowledge, that is, a discovery of hidden truths.
- A research can lead to new contributions to the existing knowledge.
- Only through research is it possible to make progress in a field.
- Research is indeed civilization and determines the economic, social and political development of a nation.

# What is the goal of science?

*The main goal of science* is to gain knowledge about the world and to apply it in ways that will better humanity.

*Science of challenges*: to describe, to predict, control, organization, and explanation facts, processes, phenomena

# *Classification of research:*

## 1. Fundamental or basic research

## 2. Applied research

### **Fundamental (or basic, or theoretical) research:**

- Basic research is an investigation on basic principles and reasons for occurrence of a particular event or process or phenomenon.
- Study or investigation of some natural phenomenon or relating to pure science are termed as basic research.
- It provides a systematic and deep insight into a problem and facilitates extraction of scientific and logical explanation and conclusion on it.
- It helps build new frontiers of knowledge. The outcomes of basic research form the basis for many applied research.
- Researchers working on applied research have to make use of the outcomes of
- basic research and explore the utility of them.
- Research on improving a theory or a method is also referred as fundamental research.
- Attempts to find answers to the following questions actually form basic research.
- Why are materials like that?      • What are they?      • How does .....?      • Why is .....?
- Fundamental research leads to a new theory or a new property of matter or even the existence of a new matter, the knowledge of which has not been known or reported earlier.



# *Fundamental research on*

- (1) astronomy may leads to identification of new planets or stars in our galaxy,
- (2) elementary particles results in identification of new particles,
- (3) complex functions may leads to new patterns or new properties associated with them,
- (4) differential equations results in new types of solutions or new properties of solutions not known so far,
- (5) chemical reactions leads to development of new compounds, new properties of chemicals, mechanism of chemicals reactions, etc.,
- (6) medicinal chemistry leads to an understanding of physiological action of various chemicals and drugs,
- (7) structure, contents and functioning of various parts of human body helps us identify the basis for certain diseases.

## Basic research

## Applied research

Seeks generalization

Studies individual or specific cases without the objective to generalize

Aims at basic processes

Aims at any variable which makes the desired difference

Attempts to explain why things happen

Attempts to explain why things happen

Tries to get all the facts

Tries to correct the facts which are problematic

Reports in technical language of the topic

Reports in common language

## Отрасли наук

### Естественные науки:

- 1 Физико-математические науки
- 2 Химические науки
- 3 Биологические
- 4 Науки о Земле и географические науки

### Гуманитарные науки

- 1 Исторические науки
- 2 Филологические науки
- 3 Политические науки
- 4 Философские науки
- 5 Психологические науки

### Социальные науки и бизнес, услуги

- 1 Социальные науки и услуги
- 2 Экономика

### Образование

- 1 Педагогические науки
- 2 Психологические науки

### Юридические науки

### Технические науки и технологии

### Сельскохозяйственные и ветеринарные науки

### Военное дело и безопасность

### Здравоохранение и социальное обеспечение (медицина)

### Branches of Science

### Natural Sciences:

- 1 Physics and mathematics
- 2 Chemical sciences



What is the area of research?

## Areas of research:

- science,
- technology,
- languages,
- literature,
- history,
- sociology.

**What are the methods of research?**



# Research methods:

- study,
- experiment,
- observation,
- analysis,
- comparison,
- reasoning.

What are  
the Objectives of Research?

# The prime objectives of research:

- (1) to discover new facts,
- (2) to verify and test important facts,
- (3) to analyze an event or process or phenomenon to identify the cause and effect relationship,
- (4) to develop new scientific tools, concepts and theories to solve and understand scientific, and nonscientific problems,
- (5) to find solutions to scientific, nonscientific and social problems,
- (6) to overcome or solve the problems occurring in our every day life.



What

Makes

People

do

Research?

# **The motivations of research:**

- **(1) to get a research degree (Master, Doctor of Philosophy (Ph.D.)) along with its benefits like better employment, promotion, increment in salary, etc.**
- **(2) to get a research degree and then to get a teaching position in a college or university or become a scientist in a research institution**
- **(3) to get a research position in countries like U.S.A., Canada, Germany, England, Japan, Australia, etc. and settle there**
- **(4) to solve the unsolved and challenging problems**
- **(5) to get joy of doing some creative work**
- **(6) to acquire respectability**
- **(7) to get recognition**
- **(8) curiosity to find out the unknown facts of an event**
- **(9) curiosity to find new things**
- **(10) to serve the society by solving social problems.**

# Thesis or Ph.D.

- Prof.P. Balaram:

Ph.D. degree is a passport to a research career.

- Thesis or Ph.D. research inherently involves those aspects of subject that cannot
- be actually learned from textbooks or from lecture courses.
- It is the point where the values, traditions and styles of science are transmitted from one generation to another.

# Importance of Research:

- Research is important both in scientific and nonscientific fields.
- In our life new problems, events, phenomena and processes occur every day. Scientists have to undertake research on them and find their causes, solutions, explanations and applications.
- Research assists us to understand nature and natural phenomena.



# Important avenues of research:

- (1) A research problem refers to a difficulty which a researcher or a scientific community or an industry or a government organization or a society experiences. It may be a theoretical or a practical situation. It calls for a thorough understanding and possible solution.
- (2) Research on existing theories and concepts help us identify the range and applications of them.
- (3) It is the fountain of knowledge and provide guidelines for solving problems.
- (4) Research provides basis for many government policies. For example, research on the needs and desires of the people and on the availability of revenues to meet the needs helps a government to prepare a budget.
- (5) It is important in industry and business for higher gain and productivity and to improve the quality of products.
- (6) Mathematical and logical research on business and industry optimizes the problems in them.
- (7) It leads to the identification and characterization of new materials, new living things, new stars, etc.
- (8) Only through research inventions can be made; for example, new and novel phenomena and processes such as superconductivity and cloning have been discovered only through research.
- (9) Social research helps find answers to social problems. They explain social phenomena and seek solution to social problems.
- (10) Research leads to a new style of life and makes it delightful and glorious.

## *Kinds of basic and applied researches:*

### *Normal and Revolutionary Researches*

- **Normal research** is performed in accordance with a set of rules, concepts and procedures called a paradigm, which is well accepted by the scientists working in that field.
- **Normal research** is something like puzzle-solving: interesting, even beautiful, solutions are found but the rules are remain same.

### *Revolutionary Research.*

- In this normal research sometimes unexpected novel results and discoveries are realized which are inconsistent with the existing paradigm.
- This is marked by a paradigm shift and a new paradigm emerges under which normal scientific activity can be resumed.

## Quantitative and Qualitative Methods

**Quantitative research** is based on the measurement of quantity or amount.

**Quantitative research** is a process which expressed or described in terms of one or more quantities.

The result of this research is essentially a number or a set of numbers.

**The characteristics of quantitative research/method are:**

- It is numerical, non-descriptive, applies statistics or mathematics and uses numbers.
- It is an iterative process whereby evidence is evaluated.
- The results are often presented in tables and graphs.
- It is conclusive.
- It investigates the what, where and when of decision making.

Statistics is the most widely used branch of mathematics in quantitative research. It finds applications not only in physical sciences but also in economics, social sciences and biology.

## Other Types of Research

- action research (fact findings to improve the quality of action in the social world),
- explanatory research (searching explanations for events and phenomena, for example finding answer to the question why are the things like what they are?),
- exploratory research (getting more information on a topic) and comparative research (obtaining similarities and differences between events, methods, techniques, etc.).

### Assignment:

- (1) List out at least 10 theoretical and applied methods which you have learned in your UG, PG courses and write their features in two or three sentences.
- (2) Write at least 20 questions in your subject the investigation of which forms basic research. Then point out how many of them have already been solved and how many were found in applications.
- (3) Distinguish between theory and experiment.
- (4) Write a note on importance of theory in basic and applied researches.
- (5) Bring out the importance of inter-disciplinary research.



## A Problem Statement

A problem statement is stated as a question

The question should begin with one of the following words: (Which or How)

The form of the question should be:  
Which or How will the Independent Variable affect the Dependent Variable

## Examples of Problem Statements



How will the height of the ramp affect the distance the car will travel?

Which amount of salt dissolved in water will freeze in the shortest period of time?



## Examples of Hypothesis



*I think* the car on the 8 cm high ramp will travel the farthest distance from the end of the ramp



*I think* the ice cube with the least amount of salt (1 tsp) will freeze in the shortest period of time

**A hypothesis** is

either *suggested* explanation for an observable phenomenon, or a reasoned prediction of a possible causal correlation among multiple phenomena.

**A theory** is a tested, well-substantiated, unifying explanation for a set of verified, proven factors. A theory is always backed by evidence; a hypothesis is only a suggested possible outcome, and is testable and falsifiable.

## *Research methodology-*

the process used to collect information and data for the purpose of making business decisions.

The methodology may include publication research, interviews, surveys and other research techniques, and could include both present and historical information.

