Chapter I - General introduction to Scientific Research

I.1. Scientific English and Bibliographic research, what is it about?

This teaching aims to introduce, to the students, the basics of scientific research, bibliographic research and scientific writing.

I.1.2. Objectives

The key objectives of this learning are:

- Introduce to the students the basics of scientific research and methodology.
- Teach them how to carry out a targeted bibliographic search for scientific papers (articles) and documents (documentary research)
- Demonstrate to students the appropriate exploitation of scientific documents (articles analysis and reviewing), and their use as references in scientific writings and communication.
- This training will also initiate the student to carry out a personal work (manuscript, dissertation, thesis), and its communication (oral presentation and poster).

I.1.2. Contents

This teaching will be developed in following chapters:

1. General introduction to Scientific Research
2. Bibliographic Research: Methodology of searching scientific documents.
3. Scientific Publications reviewing: Analysis of scientific articles and documents.
4. Scientific Writing: Thesis and dissertation.
5. Scientific Communication (overview of different forms of scientific communication).
6. Oral Communication of Scientific work (Oral presentation of a scientific work).
7. Poster communication (Conception and presentation of Posters).

I.2. Scientific Research

I.2.1. Science

I.2.1.1. Definitions

- Science is generally defined as the Intellectual and practical activity covering the systematic study of the structure and behaviour of the physical and natural world, through observation and experiment.

- It also refers to a systematic and organized body of knowledge in any area of inquiry that is acquired using the **Scientific Research**.

I.2.1.2. Characteristics

- Objective: Objectivity means the ability to see and accept facts as they are, not as one might wish them to be.

- Verifiable (empirical): Scientific knowledge is based on verifiable evidence (concrete factual observations) so that other observers can observe, weigh or measure the same phenomena and check out observation for accuracy.

- Neutral: Science only seeks knowledge. How this knowledge is to be used, is determined by societal values. Knowledge can be put to differing uses. Knowledge about atomic energy can be used to cure diseases or to wage atomic warfare.

- **Reliable and reproducible:** Scientific knowledge must occur under the prescribed circumstances not once but repeatedly. It is reproducible under the circumstances stated anywhere and anytime.

- Self-correcting: Because science is empirical, new evidences may contradict or correct the old ones.

- Progressive: Because science is empirical and self-correcting, it is also progressive. Furthermore, Science never claims to have the whole truth. New information may make current knowledge obsolete.

- **Cumulative:** Each new knowledge is based on prior knowledge. In science, any piece of research is based on previous achievements and they are all steps forward in any area of scientific knowledge: health sciences, social science, technical science or any other.

I.2.2. Scientific research

Scientific research is defined as the systematic investigation of scientific theories and hypotheses. It is a dynamic process of a rational approach to verify hypotheses, observe and examine phenomena, solve problems, and to obtain precise answers. It is designed to produce, develop and contribute to generalizable knowledge. This process is characterized by the fact that it is systematic, rigorous and leads to the acquisition of new knowledge.

This definition excludes:

- Some medical and clinical practices, even if trying an unproven treatment
- Program or courses evaluation (unless plan to publish results)
- Some academic activities, such as teaching courses (even if scientific)

I.2.2.1. Characteristics

- Scientific methods: Adopts organized and systematized procedure for investigation.

- Rigor: A good theoretical base and a sound methodological design add rigor to a purposive study. Rigor connotes carefulness, scrupulousness, and the degree of exactitude in research investigations.

- Empirical Observation: The scientific method is empirical; it relies on direct observation of the world, and disdains hypotheses that run counter to observable fact.

- Verifiable or observable evidence: Factual observations can see and check.

- Purposive investigation: It is not merely a compilation of the information but a purposive investigation or search for a solution to a problem

- Accuracy: Describing what really exist. Truth or correctness of a statement or describing things exactly as they are

- Scientific Precision: Making it as exact as necessary. It avoids colourful literature and vague meanings. It requires applying some tools of data analysis

- Systematization: Attempting to collect all the relevant data or collecting data in a systematic and organized way so that the conclusions drawn are reliable, generalisation of theories or models

- Finding answer: It aims at finding answer to a question, or solution to a problem

- Replicable Experiments: Scientific experiments are replicable; duplicated experiment gives the same results. Scientists are supposed to publish enough of their method so that another person, with appropriate training, could replicate the results.

- Objective Approach: The scientific method is objective. It relies on facts and on the world as it is, rather than on beliefs, wishes or desires.

- Publication:

I.2.2.2. Functions and Aims

- Discover new information and relationships to expand and verify existing knowledge.
- Gather new knowledge and discovery of new general principles.
- Investigate and verify previous hypothetical propositions about phenomena.
- Solve problems and decision making purposes.
- Describe and Explain phenomena, facts, and theories
- Predict events by relating them empirically to antecedent in time
- Control events by manipulating their related data and variables.

I.2.2.3. Types of scientific research

The Scientific Research may broadly be classified into the following major types:

- Fundamental *vs* applied research: Fundamental (known also as Pure or Basic) research implies that there are no explicit practical implications or uses of the research conducted. In contrast, applied research aims directly at solving a problem found in practice, and to apply findings and results.

- Theoretical *vs* Empirical research: theoretical research implies using already existing resources or ”inventing” new ideas in order to form new theories within a particular field of science. Empirical research, on the other hand, involves applying theory onto a first-hand set of data and compares the outcome with expected and hypothesized outcomes from theory. The term “empirical” emanates from the Greek words for “observation” or “experiment”, and emphasizes the requirement for use of first-hand sources.

- Descriptive *vs* Explanatory research: descriptive research only aims at providing a clear picture of the data itself (answers the “what”, “when”, “where” and “who” questions), without any claims of generalizability. Exploratory research, on the other hand, tries to uncover the relationships between variables (i.e. causal relationships) (answers the “why” questions). Moreover, the exploratory research also aims at generalizing the results of sample to a population.

- Primary *vs* Secondary research: In general, Primary research concerns research that deals with collecting first-hand empirical data (new and original data) by using commonly accepted research procedures. Secondary research, on the other hand, does not involve collection of first-hand data, but instead relies on analysis of already existing empirical data sets (secondary sources, or secondary data). Usually, secondary research is also undertaken in primary research in order to examine what research has been conducted in the past in a particular field of interest. Thus, secondary research can serve as a precursor to research design.

I.2.2.4. Scientific research methodology

Scientific Research process, in any science area, is subjected to the principles of Scientific Method.

a. Research approaches

Depending on adopted reasoning in research process, four major approaches could be defined:

- Inductive approach: using a reasoning which goes from the general to the particular, from the principle to the consequence, from the large to the small. In this case, the conclusion is of no greater generality than the premises.

- Deductive approach: reasoning that goes from the particular to the general, from facts to laws. It implies that the conclusion is of greater generality than the premises.

- Analytical Approach: based on the data collection either quantitative or qualitative from existing works, decomposition of data of study going from the most complex to the simplest, then analysis of each decomposed data to draw conclusions.

- Empirical approach: based on, concerned with, or verified by observations or experiences in laboratory or field.

b. Research strategy

Scientific research, as process, is a multistep activity that can be divided into three major phases: (i) Research Conception (Design), (ii) Research Implementation and (iii) Findings Dissemination. These steps are applied to all fields of science, to all levels of scientific research (from the student level to the accredited researcher level), and they are strictly subjected to the rules of scientific method. Moreover, scientific research is usually carried out iteratively, through theory development and theory testing. Such an iterative process steps are summarised hereafter:

1. **Make Observation:** generally the first step in scientific method is to make observations about a subject (even if it's informally). Ideally, notes on observations are recorded and may help formulate a hypothesis.
2. **Define Problem:** which consists in defining the topic (theme) of research by specifying and justifying (based on observation) the problem that will be treated during the research process.
3. **Question and Hypothesis Formulation:** Suggest a testable (verifiable) hypothesis to explain or predict the outcome of the research problem, precise testable statements or questions of research.
4. **Background research and Literature Review:** by conducting a bibliographic research, collection and summarising of prior relevant studies (previous data collection).
5. **Research Design and experiment:** it consists of operationalization of research concepts. Design and perform experiments to test suggested hypothesis.
6. **Data collection and analysis:** it consists of Recording data (and observations) of the former step (4), compilation and analysis the meaning of these data.
7. **Draw Conclusion:** It consists of concluding whether to accept or reject the hypothesis (answer or not the asked question, resolve or not the defined problem). There is no right or wrong outcome to an experiment, so either result is fine. Accepting a hypothesis does not necessarily mean it's correct. Sometimes repeating an experiment may give a different result. In other cases, a hypothesis may predict an outcome, yet researcher might draw an incorrect conclusion. Whether

accepted or rejected the hypothesis, researchers likely learns something about the subject and he may wish to revise the original hypothesis or form a new one for a future experiment.

8. **Communication of results:** the results may be compiled into a lab report (thesis or dissertation) or formally submitted as a research paper for publication in accredited scientific journal.

Described in this way the research process is given the impression of linearity, yet research investigation is often an **iterative** process whereby the process of conducting the research will give rise to new ideas which, in turn, feed back into the data collection and analysis stage. Decisions made early in the research process are often revisited in the light of new insights or practical problems encountered along the way.

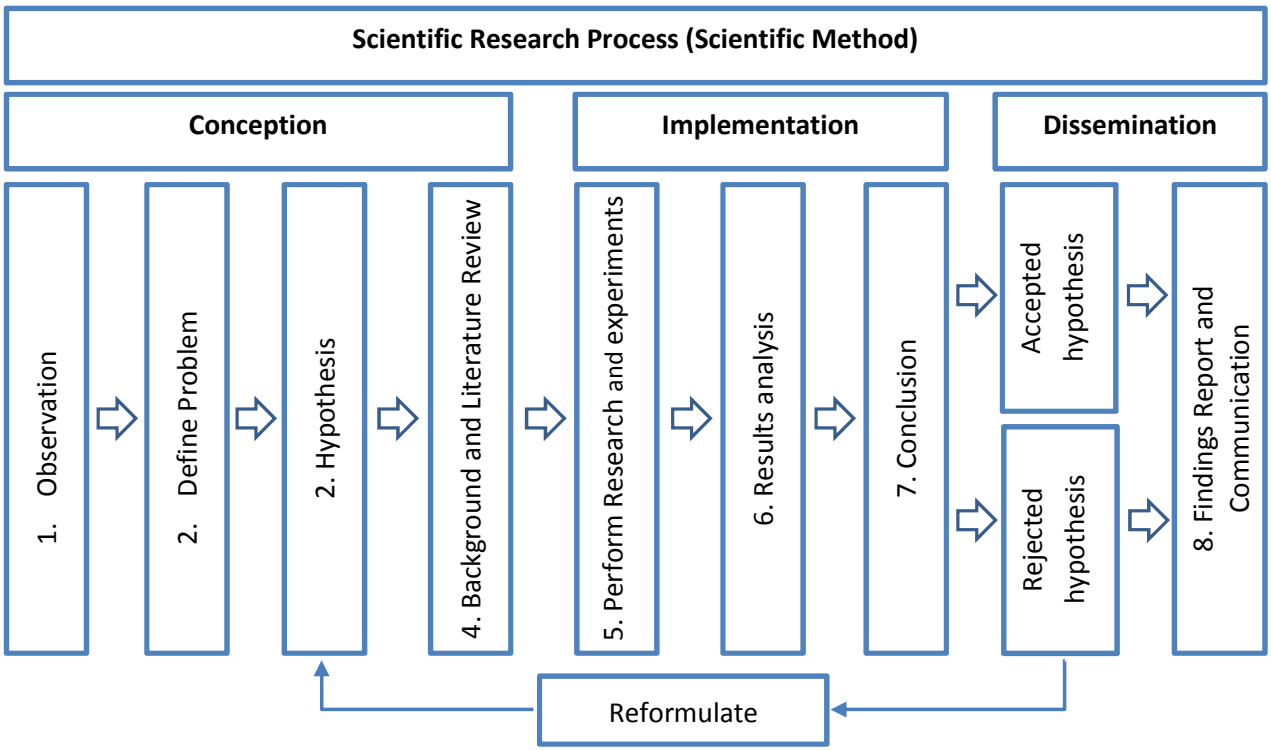

Figure 1. Flowchart of Scientific Research Process (adapted from **Lockström, 2007**)

I.3. Scientific Research in Biomedical Sciences

I.3.1. Biomedical Sciences research

Biomedical sciences are a fast-growing and promising research area focused on biological approaches to health and illness issues. Their ultimate aim is to contribute to the improvement of human and animal's health. This general field of research includes many areas of both the life and physical sciences. Developments in genetics, immunology, and neurobiology have provided new insights in issues of health and illness and inspired the development of innovative diagnostic and therapeutic tools.

Biomedical researchers study biological processes and diseases with the ultimate goal of developing effective treatments and cures. Biomedical research is an evolutionary process requiring careful experimentation by many scientists, including biologists and chemists. Discovery of new medicines and therapies requires careful scientific experimentation, development, and evaluation.

Different types of biomedical research take place in different organizational settings. Fundamental biomedical research can be found mainly in research institutions and universities, whereas applied biomedical research is for the most part conducted in industrial laboratories.

I.3.2. Classification of Biomedical study types

In principle, Biomedical research is classified into primary and secondary research. While secondary research summarizes available studies in the form of reviews and meta-analyses, the actual studies are performed in primary research. Three main areas are distinguished: (i) Basic medical research, (ii) Clinical Research, and (iii) Epidemiological research. Figure 2 gives an overview of the different study types in medical research.

I.3.2.1. Basic research

Basic Biomedical research (otherwise known as experimental research or fundamental research) includes animal experiments, cell studies, biochemical, genetic and physiological investigations, and studies on the properties of drugs and materials. The procedure and the experimental design can be precisely specified and implemented. Basic research also includes the development and improvement of analytical procedures such as analytical determination of enzymes, markers or genes; imaging procedures such as computed tomography or magnetic resonance imaging; and gene sequencing such as the link between eye color and specific gene sequences. The development of biometric procedures such as statistical test procedures, modeling and statistical evaluation strategies also belongs here.

I.3.2.2. Clinical studies

Clinical studies include both interventional (or experimental) studies and noninterventional (or observational) studies. Interventional studies implies clinical experiments on patients such as clinical drug study, and purposes of studying or demonstrating the clinical or pharmacological effects of drugs, to establish side effects, or to investigate absorption, distribution, metabolism or elimination. Interventional studies also include studies on medical devices and studies in which surgical, physical or psychotherapeutic procedures are examined.

In contrast to clinical studies, noninterventional study is a study in the context of which knowledge from the treatment of persons with drugs in accordance with the instructions for use specified in their registration is analysed using epidemiological methods.

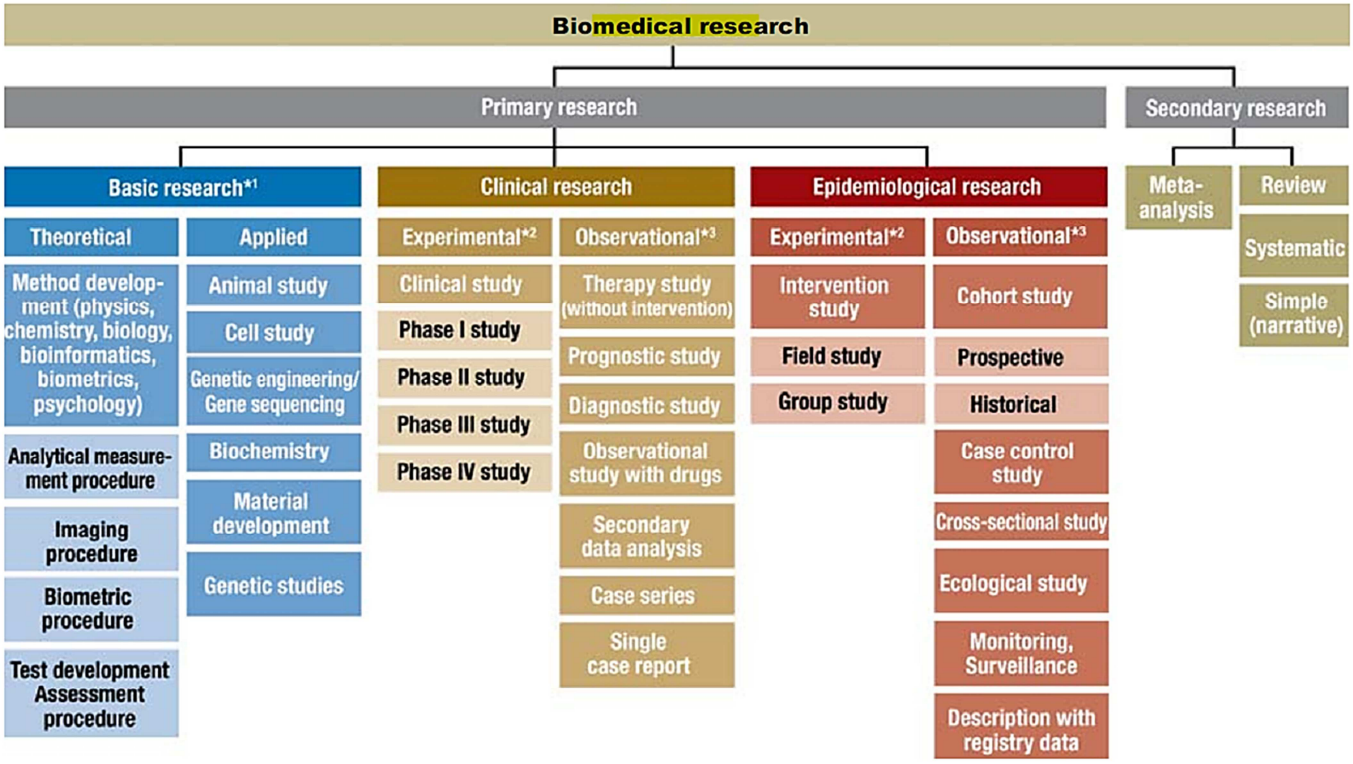

Figure 2. Different types of Biomedical research (Adapted from Röhrig et al., 2009) .

I.3.2.3. Epidemiological studies

The main point of interest in epidemiological studies is to investigate the distribution and historical changes in the frequency of diseases and the causes for these. Analogously to clinical studies, a distinction is made between experimental and observational epidemiological studies.

Interventional studies are experimental in character and are further subdivided into field studies (sample from an area, such as a large region or a country) and group studies (sample from a specific group, such as a specific social or ethnic group).

Observational epidemiological studies can be further subdivided into cohort studies (follow-up studies), case control studies, cross-sectional studies (prevalence studies), and ecological studies (correlation studies or studies with aggregated data).

I.3.2.4. Secondary studies

It consist of using secondary resources (others researches) to evaluates or synthesizes data collected during primary research. The aim of this type of studies is to summarize available studies (primary studies) in the form of reviews and meta-analyses.

I.3.3. Ethics in biomedical research

Biomedical studies are submitted to rigorous and strict rules of Ethics and Bioethics. Bioethics is the study of the typically controversial ethical issues emerging from new situations and possibilities brought about by advances in biology and medicine. It is also a kind of moral discernment as it relates to biomedical policy, practice and research. Bioethics helps to keep biomedical research humane and more moral.

Biomedical research must fully respect bioethics rules in each and every level and stage of its realization. Thus, important and justified ethical considerations may restrict studies with optimal scientific and statistical features.

I.4. Bibliographic research, scientific writing and publishing

Bibliographic research, scientific writing and publishing are three key activities in research process.

Bibliographic research, also known as literature research, Literature search is a key step in performing good authentic research. The major part of bibliographic research is usually carried out in the beginning of research project (Research conception). Nevertheless, literature research is a continuous activity throughout the research process.

The literature review involves the collection and summary of prior studies that are relevant to the hypothesis or research question. This process assesses what is already known about the problem and refines research questions for extending knowledge in this field. It helps in formulating a research question and planning the study. The available published data are enormous; therefore, choosing the appropriate articles relevant to the study in question is an art. It is a time-consuming and very tiring task if not carried out in a step-wise manner.

The reasons for conducting literature search are numerous, that include drawing information for making evidence-based guidelines, a step in the research method and as part of academic assessment. However, the main purpose of a thorough literature search is to formulate a research question by evaluating the available literature.

Scientific writing and publishing is the ultimate step in the research process, it marks the endpoint of research. Scientific publication is evidence that research has been performed, completed, and accepted. Publication is also an indicator of achievement of a certain academic standard. Publishing is the basis for further opinions, views and critiques from fellow professionals and academics separated by time and distance. Most importantly, it represents a permanent record of scientific work that has been completed.

Scientific writing and publication is an important component of scientific research, it comprises a whole range of forms, including theses, books and book chapters, grant applications, course syllabi, proffered abstracts, and journal articles (the highest level of scientific writing). Scientific writing and publishing is the most important mean for science work communication, results and findings dissemination, and Science vulgarization.

I.4. Language of Science and Scientific language

Science is itself a universal language and may be expressed in any world language. However, for the dissemination of science and knowledge researches could be expressed and communicated in worldwide understood language. It's indisputable that English language is, nowadays, the language of science expression for historical events, not through any inherent characteristics that make it better suited to the task. On the other hand, scientific journals and reviews are presently the main source of scientific research and information. Scientific papers, published in these journals and reviews, are considered as the highest level of scientific production. However, almost all of these journals and reviews are expressed in English language. The ever-growing status of the scientific journals and articles is paralleled by the ever-growing use of English as the medium knowledge dissemination. Thus, the researcher must adapt to this reality, and must at least learn this language of science so that he can, first of all, read and understand what other researchers do (understand the literature) and, secondly, so that he can publish and transmit his research to the whole scientific community.

Scientific language also refers to the style in which scientific information is communicated (written or orally communicated), and which is completely different of literary style. Scientific writing has a distinctive style, despite the language in which it is written the scientific text must be clear and directly comprehensible, succinct and concise, precise and logical. In scientific writing, it is also essential to consider the audience to whom the message is addressed.

In conclusion, the proper structuring of the scientific project, the rigorous respect for the methodology of scientific research, a relevant bibliographic research, the proper exploitation of literature, the proper implementation of research, a relevant analysis of the results and the logical definition of the conclusions, in addition to an appropriate scientific redaction, are all essential elements for the success of scientific research.