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Manual on Scientific  
Communication for  
Postgraduate Students  
and Young Researchers in  
Technical, Natural and Life  
Sciences

*Authored by Oswald Van Cleemput  
and Luciano Saso*





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# MANUAL ON SCIENTIFIC COMMUNICATION FOR POSTGRADUATE STUDENTS AND YOUNG RESEARCHERS IN TECHNICAL, NATURAL AND LIFE SCIENCES

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Authored by **Oswald Van Cleemput**  
and **Luciano Saso**

# **Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural and Life Sciences**

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Edited by Oswald Van Cleemput and Luciano Saso

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# Meet the authors



Oswald Van Cleemput is an emeritus professor of Ghent University in Belgium. He has been the head of the Analytical and Physical Chemistry Department of the Faculty of Bioscience Engineering; he was the dean of this faculty and was a member of the university board. He has been teaching Physical Chemistry as well as Research Methodology and Special Didactics. He is still teaching Scientific Communication in developing countries. His field of research is nitrogen and carbon dynamics in terrestrial and aquatic environments, with special attention to greenhouse gases. He is an author and coauthor of over 500 papers, of which 220 are peer-reviewed. He edited 18 books. Among different scientific awards, he contributed to the award of the Nobel Peace Prize for 2007 to the Intergovernmental Panel on Climate Change.



Prof. Luciano Saso (Faculty of Pharmacy and Medicine, Sapienza University of Rome, Italy, <http://en.uniroma1.it/>) received his doctorate degree in Pharmaceutical Sciences from Sapienza University in 1992. He is the author of more than 200 scientific articles published in international journals (total impact factor >500, H-index Google Scholar 34, Scopus 28). He coordinated several research projects in the field of pharmacology and has been a referee for many national and international funding agencies and international scientific journals in the last 25 years. He has extensive experience in international relations, and he is currently the vice-rector for the European University Networks and a member of the Council for Doctoral Education at Sapienza University of Rome. He has been a member of the Steering Committee of the UNICA network of the universities from the capitals of Europe (<http://www.unica-network.eu/>) for two mandates (2011–2015), and, in October 2015, he was elected president for the period 2016–2019.





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## **Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural, and Life Sciences 1**

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## Preface

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This manual is intended to help you, students and young researchers, with all problems linked to scientific communication. After all, you should never forget what Lois DeBakey wrote “...the greatest truths, poorly communicated, remain unconvincing.”

Scientific research is a very challenging and complex activity. It starts with an idea, emerging from discussions with colleagues or just from reading existing literature. Or, in many cases, a subject is put forward by the supervisor. As a result, relevant literature will be explored; a hypothesis will be developed, followed by a research plan and the execution of it. Many useful and less useful results will be collected, and, hopefully, you will be proud of everything you found. But, this is definitively not the end of the story. All obtained results need to be arranged in a proper way, confronted and discussed with existing knowledge, and put in a clear format. And, it is still not finished. So far, science is not making any step forward yet. There is a final necessary step! The results, discussion, and conclusions must be made public. Other scientists must be able to read them and to check the information. In fact, development of science is a continuous process. Within the scientific world, it follows a kind of *spiral*. Existing knowledge is published and can be read by other scientists. It gives them next to the knowledge of the state of the art also new ideas. These new ideas can be developed and worked out, leading to new publications, which can be read again by other scientists, etc.

The paragraph above summarizes a long process in about ten lines! But, to have a clear full progress with a good efficiency in science development, it is important that *all collected information is clearly presented, easy to read, simple but precise, and always honest*.

Therefore, it is of utmost importance that you present information in an as good as possible way. This refers not only to the content itself of the document but also to the way of writing or presenting. Depending on the type of reader/audience, the vocabulary can be different and tables and figures can be more or less complex or even the whole structure. Anyway, it is important that all your information is published, also according to eventually local or even international rules. This is vital for science to progress, but also for yourself. It helps building up a carrier if many colleagues read your documents and if they cite your work. This is valid for any scientific document, such as a journal article or review, an abstract, a scientific presentation, a poster, a thesis, a project or grant proposal, or even a report. In addition, your scientific output shows your expertise, and this can help with job opportunities.

Wolfgang Pauli wrote once “I don’t mind if you think slowly, Doctor; but I do mind if you publish faster than you think.” With this citation, we want to put emphasis on the difficulty of scientific communication. For sure, many factors have an influence, such as the choice of the research topic, the quality of supervision, and even the availability of

sufficient financial resources. However, our experience learns that you can perfectly be trained in scientific communication.

At present, revolutionary changes of the global structure of scientific communication are taking place. Next to the traditional (printed) channels, electronic channels become stronger and stronger, and they offer enormous possibilities, such as rapid consultation, colored documents, pictures, etc. They form a reliable and stable communication channel of scientific knowledge. Libraries still hold not only printed editions but also manage electronic editions. They are usually active in different networks, and it is their task to systematize, archive, and provide adequate reflections and to organize systems of literature navigation.

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# Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural, and Life Sciences

*A practical guide for the preparation of theses, papers, posters, and other scientific documents*

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Oswald Van Cleemput and Luciano Saso

Additional information is available at the end of the chapter

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## Abstract

The “Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural and Life Sciences” is meant to be a practical guide for the preparation of theses, papers, posters and other scientific documents. Upon going through the different chapters, the readers should be able to critically search for relevant literature, to correctly define and execute a research topic or project, to correctly write a scientific document, to know the characteristics of the different parts of a M.Sc or PhD thesis and a scientific paper, to correctly interpret publishing ethically sensitive material, to understand problems about falsification, fabrication of data, plagiarism and ranking of authors, and to prepare and present a good poster.

**Keywords:** scientific communication, thesis, dissertation, manuscript, scientific paper, poster, literature search, plagiarism

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## 1. Introduction

This manual is part of the results of the project TRAIN (Training and Research for Academic Newcomers). The purpose of TRAIN was to develop, implement, and evaluate a professional development training for new academics (assistants, junior professors, post-docs, and postgraduate students who aim for an academic career). The objectives were to improve (1) student learning, (2) their research, (3) their contribution to society and industry, (4) collaboration among new academics, (5) expanding their networks, (6) enhancing their capacity for educational leadership, and (7) enabling them to positively influence change.

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The training consisted of seven modules:

- 1a. Research Methodology, Scientific Writing and Result Presentation (humanities and social sciences);
- 1b. Research Methodology, Scientific Writing and Result Presentation (technical, natural, and life sciences);
- 2a. Higher Education Didactics (humanities and social sciences);
- 2b. Higher Education Didactics (technical, natural, and life sciences);
3. Preparing funding Applications & Project Management;
4. Presentation & Communication Skills;
5. Entrepreneurial Skills;
6. Networking & Teamwork;
7. Designing Higher Education Curricula.

The project, **funded by the King Baudouin Foundation** (Belgium), covered collaboration between EU-partners (Ghent University (coordinator), University of Kent, Uppsala University, La Sapienza, University of Rome, University of Potsdam/UP Transfer GmbH, Santander Group, and the King Baudouin Foundation), and Western Balkan partners (University of Belgrade, University of Novi sad, University of Montenegro, and University of Sarajevo).

**This manual covers Module 1b “Research Methodology, Scientific Writing, and Result Presentation (technical, natural, and life sciences).”**

*Some ideas and examples used in the text were provided by Dr. Steve A. Quarrie, Guest Professor, Biology Faculty, Belgrade University, Serbia.*

*Consulted and used literature to the text in the different chapters is listed at the end of the Chapter.*

### **1.1. Learning outcomes**

After successfully following Module 1b “Research Methodology, Scientific Writing, and Result Presentation (technical, natural, and life sciences)” of TRAIN, the participants should be able to

- critically search for relevant literature;
- review relevant literature;
- correctly define and execute a research topic or project;
- correctly write a scientific document;
- know the characteristics of the different parts of a M.Sc or PhD thesis and a scientific paper;
- correctly interpret publishing ethical sensitive material, understand problems about falsification, fabrication of data, plagiarism, and ranking of authors; and
- prepare and present a good poster.

## 2. Research methodology

Research in the technical, natural, and life sciences is a very challenging activity requiring several elements which are not easy to combine to create a “fertile” environment for young researchers (YR) and doctoral candidates (DC).<sup>1</sup> Some of them got:

***Excellent training during previous studies.*** YR and DC should be selected among graduates with excellent training during previous studies (Bachelor’s and Master’s degree), possibly with previous exposure to research activities during their theses or dissertation at the home institution or abroad.<sup>2</sup> Undergraduate students should be informed through “career days” and similar activities that the research path is only one of their possibilities for their professional development and to choose it only if highly motivated. Placements in enterprises and other nonacademic organizations could also be beneficial during undergraduate studies to show them the full spectrum of professional tracks and strengthen the motivation of the students really interested in research.

***Choice of the research topic.*** YR and DC should be strongly encouraged to choose a topic of their interest for their PhD program and their future academic career. Rotations through different laboratories and departments could be very beneficial to show them how research is performed in different fields before they make the final choice.

The research institution should try to create strong research teams having a sufficient critical mass of excellent researchers.<sup>3</sup> Indeed, with some exceptions, in the technical, natural, and life sciences, research is conducted by teams. Isolated researchers are very rarely successful.

YR and DC should be advised to balance “safe research paths” with more risky and innovative projects and encouraged to work not only on mono-disciplinary topics but also on interdisciplinary ones in collaboration with colleagues from different institutions. However, in seeking exposure to different subjects, YR and DC should obtain a good general knowledge, being careful not to have just generic notions.

***Identification of original and relevant research goals.*** YR and DC joining strong research teams will be very much facilitated because their supervisors will be able to give them clear indications. However, they should always be encouraged to study very well the literature of their research field to get new and original ideas. In addition to free databases such as

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<sup>1</sup>Persons conducting research and/or aiming to submit a thesis with the goal of acquiring a doctoral degree (<http://www.eua.be/arde>).

<sup>2</sup>International programs such as LLP/Erasmus or Erasmus Mundus (now Erasmus+ [http://ec.europa.eu/programmes/erasmus-plus/index\\_en.htm](http://ec.europa.eu/programmes/erasmus-plus/index_en.htm)) provide plenty of opportunities for undergraduate students.

<sup>3</sup>Striving for excellent research is fundamental to all doctoral educations and from this, all other elements flow. Academic standards set via peer review procedures and research environments representing a critical mass are required. The new academic generation should be trained to become creative, critical, and autonomous intellectual risk takers, pushing the boundaries of frontier research. Doctoral candidates should find good working conditions to empower them to become independent researchers taking responsibility at an early stage for the scope, direction, and progress of their project. These should include career development opportunities, in line with the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers.

([http://ec.europa.eu/euraxess/pdf/research\\_policies/Principles\\_for\\_Innovative\\_Doctoral\\_Training.pdf](http://ec.europa.eu/euraxess/pdf/research_policies/Principles_for_Innovative_Doctoral_Training.pdf))

Medline,<sup>4</sup> Google Scholar,<sup>5</sup> etc., the availability of other bibliographic resources such as Scopus,<sup>6</sup> Web of Science,<sup>7</sup> Scifinder Scholar,<sup>8</sup> etc. (possibly with access to the full texts of the articles) is essential. These resources are often considered expensive by research institutions, but they allow saving money and time avoiding repetition of experiments and waste of time on projects designed without adequate knowledge of the scientific literature.

**High quality supervision and continuous training.** YR and DC should be supervised by one or more expert researchers available on daily basis to discuss their results and willing to provide advice on how to proceed in their project.<sup>9</sup> Courses on specific subjects or on transferable skills<sup>10</sup> should be available to help them to better develop their scientific and technical knowledge or to plan a successful career outside academia if desired.<sup>11</sup>

**Availability of sufficient financial resources.** The availability of sufficient resources for the research activities such as space and equipment is essential. YR and DC should also be trained to prepare and submit grant applications under national and international funding schemes such as Horizon 2020, Cost,<sup>12</sup> European Science Foundation,<sup>13</sup> the Innovative Medicines Initiative,<sup>14</sup> the Bill and Melinda Gates Foundation,<sup>15</sup> and many others. The financial autonomy will give them also higher academic freedom.

**Availability of sufficient technical resources.** The availability of sufficient technical resources for the research activities such as space and equipment is essential. To optimize them, research institutions can centralize some of the most expensive ones, hiring technical staff capable of providing services to different research teams and minimizing the time during which expensive instruments are not used.

**International networking.** YR and DC should be encouraged to establish international collaborations through, co-tutelle program, conferences, research visits, etc. Recent scientific social networks such as [www.researchgate.net](http://www.researchgate.net), [www.academia.edu](http://www.academia.edu), [www.biomedexperts.com](http://www.biomedexperts.com), <http://academic.research.microsoft.com>, <http://publicationslist.org>, are also very useful to establish and maintain international collaborations.

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<sup>4</sup>[www.pubmed.com](http://www.pubmed.com)

<sup>5</sup><http://scholar.google.com/>

<sup>6</sup><http://www.scopus.com/>

<sup>7</sup><http://thomsonreuters.com/thomson-reuters-web-of-science/>

<sup>8</sup><https://scifinder.cas.org/>

<sup>9</sup>Excellent resources available at <http://www.eua.be/cde/publications.aspx> and <http://www.unica-network.eu/group/phd-officers-group-unica-phd-master-class>.

<sup>10</sup>Transferable skills are skills learned in one context (for example research) that are useful in another (e.g., future employment whether that is in research, business, etc.). They enable subject- and research-related skills to be applied and developed effectively. Transferable skills may be acquired through training or through work experience. It is essential to ensure that enough researchers have the skills demanded by the knowledge-based economy. Examples include communication, teamwork, entrepreneurship, project management, IPR, ethics, standardization, etc. Business should also be more involved in curricula development and doctoral training so that skills better match industry needs. ([http://ec.europa.eu/euraxess/pdf/research\\_policies/Principles\\_for\\_Innovative\\_Doctoral\\_Training.pdf](http://ec.europa.eu/euraxess/pdf/research_policies/Principles_for_Innovative_Doctoral_Training.pdf))

<sup>11</sup>Excellent resources available on the website <https://www.vitae.ac.uk/>.

<sup>12</sup><http://www.cost.eu/>.

<sup>13</sup><http://www.esf.org/>.

<sup>14</sup><http://www.imi.europa.eu/>.

<sup>15</sup><http://www.gatesfoundation.org/>.



***Collaboration with enterprises and other nonacademic institutions.*** YR and DC should be encouraged to establish collaborations with nonacademic organizations and enterprises also to create placement opportunities for the students/graduates of the institution. That will be also be useful in getting exposure to nonacademic research questions and bringing additional financial resources through contracts, donations, etc. Knowing well different employment sectors will also make researchers capable of giving advice to younger students on their career development.

***Technological transfer.*** Nowadays, exploitation of research results is more important. Research institutions should have very efficient technological transfer offices (TTO) to help YR to patent their results if appropriate. The process should be fast in order not to delay the publication process which is essential for the scientific activities of the researchers (submission of theses, career progression, project reporting, etc.). The TTO should also be entitled to refuse to patent results not considered exploitable through licensing. On the other end, the search for companies interested in the patent portfolio should be very fast because usually companies are not interested in old patents.

TTOs should also encourage YR to start spin off companies in the appropriate cases and the research institution should have policies and procedures to foster this process.

***Ethical issues (see also Chapter 7).*** YR should always give the highest consideration to copyright issues avoiding any form of plagiarism. If possible, research institutions should provide additional funds for the publications of the results in open access journals which often have publication fees of over € 1000 per article.

The order of the authors in the articles is also very important, with the first position usually given to the YR or DC who did most of the work and leaving the last one to the head of the research team.

YR and DC should be informed that submission of an article to more than one journal at the same time is not allowed and that they need to wait for the response of the journal before submitting the article to another one.

In case of animal or clinical experimentation, it is essential to abide to all national and international laws and to obtain the authorization of the Ethical Committee of the Institution whenever appropriate.

### **3. Writing and document analysis**

#### **3.1. Introduction**

Scientific communication is essential for development of science. At present, revolutionary changes of the global structure of scientific communication are taking place. Next to the traditional (printed) channels, the emergence of electronic channels becomes stronger and stronger.

Despite the enormous possibilities of the Internet, libraries are still the basic depositary of scientific knowledge. They form a reliable and stable communication channel of scientific knowledge.

Libraries not only hold printed editions, but also manage electronic editions. They are usually active in different networks. It is their task to systematize, archive, provide adequate reflections, and to organize systems of literature navigation.

The library is generally the most reliable guide when conducting research. To some extent, librarians evaluate resources for authority and quality before acquiring them for use in research. Therefore, it is advisable to become thoroughly acquainted with libraries available to scientists and to take full advantage of the resources and services they provide on-site and over the Internet.

At the same time, assessing Internet resources is a specific challenge. Scientists regularly consult and use facts and ideas from Internet sources to complement those derived from traditional printed sources. However, it should be taken in mind that printed literature is generally issued by reputable publishers, like international journal publishers, university presses and others, accepting accountability for the quality and reliability of the documents they distribute. Currently, more and more electronic publications have a comparable authority.

The development of sciences is a continuous process. Within the scientific world, it follows a kind of spiral approach. Existing knowledge is published and can be read by scientists. It gives them next to the knowledge of the state-of-the-art new ideas. These new ideas can be developed and worked out, leading to new publications, which can be read again by other scientists, etc.

To have a good efficiency of the process of science development, it is important that *all information is clearly presented, easy to read, simple but precise, and always honest*. Therefore, it is of utmost importance that the scientist him/herself presents the information in an as good as possible way. In other words, communication should be as good as possible. This refers not only to the content of his/her publication, but also to the way of writing. Depending on the type of audience/readers, the vocabulary can be different or simply the way of presentation. Anyway, it is important that the information collected by the scientist is written for a certain target public (e.g., scientists), thereby using a proper channel (e.g., a scientific journal) and a proper language. This is vital not only for the science to progress, but also for the scientist. It helps in building up his/her carrier if he/she can prove that many colleagues read his/her documents. This is valid for any scientific document, such as a journal article or review, an abstract, a scientific presentation, a poster, a thesis, a project or grant proposal, or a report.

### **3.2. General information on a scientific document**

*This chapter presents the most common recommendations for composing a scientific paper/document/thesis. If your scientific advisor or institute has specific requirements for the format of a scientific paper, check them before preparing your final draft.*

When drafting a manuscript on the computer, you should remember several rules: choose a standard, easily readable typeface (e.g., Times New Roman) and type size. A research paper must be double-spaced throughout, including quotations, notes, and the list of documents cited. When submitting a manuscript for review to a journal, it is often required to number the lines. This facilitates review.

The general lay-out rules of a thesis are often provided by the university or faculty. To prepare a manuscript for an international journal, you must go to the "Instructions to authors" of the specific journal. You can find them on the internet upon introducing the name of the journal.

A research paper does not need a title page. Instead, start from the top of the first page (either flush with the left margin or center) with the title, the authors, and their affiliation including the e-mail address of the corresponding author. Next comes the abstract of the paper. This is followed by the list of keywords. Then follows the main body of the paper: introduction, material and methods, results and discussion (eventually separated), conclusions, and a reference list. Eventually an acknowledgement can be added just before the reference list. All details are given in Section 3.3.

Place tables and illustrations as close as possible (*anyway never before*) to the parts of the text to which they refer. Give the source of the table and any notes immediately below the table. To avoid confusion between notes in the text and notes on the table, designate notes to the table with lowercase letters rather than with numerals. The title of the table appears above the table. There should not be a full stop at the end of the title.

Any other type of illustrative visual material (e.g., a picture, map, line drawing, and graph) should be labeled with "Figure" (usually abbreviated *Fig.*) followed by an Arabic numeral and the title. The numbering in scientific papers is the logic sequence of numbers; the numbering in dissertations or other books follows the chapters (e.g., **Figure 3** in Chapter 2 will be Figure 2.3). The title of a figure appears directly below the illustration. It has the same margins as the text of the paper. There is no full stop at the end of the title.

If research papers have many illustrations, you will probably want to become familiar with the various kinds of software for the creation of tables, graphs, and drawings on a computer. Set them appropriately into the text. Some promoters of theses ask to generate a list of all tables and illustrations created for the thesis.

Proofread and correct the manuscript carefully before submitting it. If you find a mistake in the final copy, make the appropriate revision.

There are at present no commonly accepted standards for the electronic submission of research papers. Each publisher has its own rules. Try to find the guidelines for authors (go to the website of the publisher) of the journal wherein you want to publish and follow them closely. The normal procedure for handling a manuscript is as follows: the manuscript is submitted to the editor of a specific journal, the editor sends it to two or more reviewers (unknown to the author(s)), the reviewers make a detailed report and suggest to the editor to accept (with or without minor or major changes) or to reject the manuscript, the editor takes a decision on the basis of the report of the reviewers and sends the comments to the author(s), the author(s) review the manuscript according to the reviewers' comments and submit a new version, eventually the new version goes back to the reviewers, who submit a new report to the editor who takes the final decision about acceptance or rejection.

### 3.3. Manuscript analysis

#### 3.3.1. Outline—IMRAD (*Introduction, Material and Methods, Results and Discussion*)

There are different basic parts of a scientific paper.

- Title: Tell what the paper is about.
- Author(s) and affiliation.

- **Abstract:** Describe the problem and summarize the major results of the research.
- **List of keywords.**
- **Introduction:** Convince the reader that the topic of the chapter is very important and that the objectives of the research are reasonable. Provide basic relevant literature.
- **Materials and methods:** Describe how you gathered the information. Give all details so that somebody else can repeat the experimental part. Methods include deductive reasoning, approximations, statistical analysis, and simulations. If the methods are well known, they are only briefly described in this section. If some parts of an existing method are changed describe in detail the changes. New methods need to be described with complete details.
- **Results:** All findings are logically presented with tables, figures, or graphs.
- **Discussion:** Interpret the results clearly, concisely, and logically.
- **Conclusions:** Summarize the main results of the research in terms of the objectives given in the introduction; describe what the results mean for the respective discipline.
- **Acknowledgements:** Acknowledge the people who helped you with the experiments, and eventually the discussion; acknowledge also the funding agency.
- **References:** List all used references (not more and not less).
- **Appendix (eventually):** Provide supplemental material, numerical examples, details of analytical procedures, novel computer programs, mathematical proofs, etc.

### 3.3.2. *Manuscript chapters*

#### 3.3.2.1. *Title, Abstract, and keywords*

It is extremely important to select a good title. It should be informative and concise. It should be as straightforward as possible, specific enough but not too narrow either. It should differentiate your research from the research by others. A good title helps to find your work in databases (via keywords). Avoid abbreviations, but also “waste words” such as “Study of ...,” “Observations of ...” Go for a short title. This is more attractive than a long one. It leads to more citations afterward.

The abstract contains the following sections: motivation and justification of the research, the objective, aim or purpose, followed by the essential used methods, a summary of the results and ending with important conclusions and impact. Make the abstract to stand alone.

Keywords are of utmost importance, as they are used for indexing (databases). They should not be too general, but rather specific.

#### 3.3.2.2. *Introduction*

<b>Introduction = answer to “What is the problem?”</b>
--

In the introduction, you should try to activate the interest of the reader in the subject. There must be a motivation for the study. In other words, why did you do this kind of study? The introduction starts rather broad narrowing to the more specific topic to be studied. Limit yourself to the most important aspects. It is important that you know very well the actual existing knowledge (state-of-the-art). You can summarize this knowledge and indicate what has not been done yet, or what can be done, e.g., looking from another angle, or what are the weak points, etc.

For sure, do not go through too many references... trying to impress the reader. Use only the relevant solid literature sources.

In the last part of the introduction, you narrow the topic to be studied, come to the hypothesis and indicate how you will test the hypothesis. From the introduction, the reader learns what he might expect in the rest of the document.

### 3.3.2.3. *Materials and methods*

**Materials and methods = answer to “how did you study the problem?”**

This part of the document gives a full and correct description of all steps executed during the research. It should be written in a logical way, by tasks. All used material must be carefully identified and described. Try to avoid trade names, unless necessary. You can put them in, e.g., italic. With the use of living material (plants, animals, and microorganisms), it is important to provide an accurate identification, such as family, genus, species, etc. Eventually, do not forget to provide climatological information, coordinates of sampled places, sample characteristics, sample size, etc.

All used methods (chemical, physical, biological, etc.) must be described in detail, allowing the reader to repeat the experiments. Add eventually the reason why a certain method or technique has been used or not. Only when the used methods are very well known or often used, you can refer to a relevant reference. However, whenever you change a specific part of a well-known method, you must clearly indicate the changes.

Provide information about the used statistical methods and computer packages. For used complicated statistical methods, provide also a reference. You must have a good knowledge about precision and accuracy. Realize that there is a difference between one sample analyzed three times, an analysis of three samples coming from one bulk sample, or an analysis of three samples coming from three different replicates. To be sure about the correct use of an experimental layout, consult a statistician. Try to become familiar with experimental setups such as a randomized block and other descriptions. The number of replicates is very important. For field experiments, you better have four than three replicates. Accurate and precise information is important for testing the hypothesis.

Try to write this section already during the experimentation. As such, you will be more alert to provide precise information and not to forget some evident information. Reproducibility is

of utmost importance. When it comes to final editing, follow the same sequence of information in the section “Materials and Methods” as in the section “Results.” It improves the link between both the sections.

#### 3.3.2.4. *Results and discussion*

**Results and discussion = answer to “what did you find and what does it mean?”**

In this section, answers are given to the questions described in the introduction. It normally begins by taking up again these questions, formulating the answers, and confronts them with the existing knowledge.

First, a few general aspects are discussed: the results section summarizes the findings in a logical way. These findings are provided in tables and figures. However, it is not done to give the same results in a table and a figure. Also, the text should complement the tables and figures, but not repeat the information. Each interpretation of the data comes after the presentation of them.

In a scientific paper, not all results need to be given, only the most relevant ones. In a student thesis, on the other hand, more results are shown than in a paper. Some of these results are not even publishable. However, realize that a quantitative approach shows the load of work, but not the importance and significance of the data. The presentation of the results can be done either chronologically or eventually by importance. The data should be accurate and consistent throughout the text with a summary of the statistical analysis. Normally the verbs are given in the past tense. Figures and tables are numbered according to their appearance, and are placed after their announcement. If results from the literature are used, make sure that the reader is informed about the difference between your own results and those from the literature.

Tables focus on specific data or estimates or parameters. They are used if data are more important than trends. On the other hand, if trends are more important than data, figures are used. Tables and figures are discussed in Chapter 3.

Tables focus on general relationships among data. The results should be presented in columns. If elements of a column need to be compared, arrange them vertically. The title should provide all information for independent reading, including used units, precision, and statistical information. Footnotes can provide vital information. Overall, the content should be concise, avoiding repetitive and redundant information. The title is given above the table and no full stop is added at the end of the table.

Avoid too busy figures, but also too much “white space”. Figures must provide all information to understand them independently and to stand alone. The title is given below the figure and there is no full stop at the end. There are different types of illustrations, i.e., graphs, drawings, or pictures. It is advisable to draw different types of figures and to select the most instructive one. The technical quality should be as high as possible.

Make paragraphs which are not too long (e.g., three, five, and eight sentences). Anyway, the English language uses short sentences. Organize a paragraph as follows: first state the answer to the question, followed first by the relevant results and then the confrontation with the knowledge from the literature. In general, a paragraph starts with the most striking information, followed by the supporting information.

The discussion section (eventually mixed with the results section) provides the interpretation of the results. Your conclusions should be compared and confronted with the existing literature. However, do not use all possible references. Limit yourself to the most important and recent ones. Negative results should be recognized. Discuss conflicting and unexpected findings. For the verbs in the discussion part, the present tense is used.

The whole section ends with a summary of the important implications, regardless of the statistical significance. Provide recommendations for future research, but, keep it concise, brief, and specific.

### 3.3.2.5. *Conclusions*

Conclusions explain the main results of the research in terms of the objectives. Avoid abbreviations, acronyms, or citations. You should avoid over-extrapolating the results. Provide readers with an interpretation of the impact of the research results, where appropriate. Consider suggestions for future research on the topic.

### 3.3.2.6. *Acknowledgments*

Acknowledgments are often of two types: general and specific. General acknowledgments include those of an institution, of a research project, or source of funds. If the research is part of your thesis or dissertation, then you might mention it here. If the paper contains a dedication, then this is where it might go. Specific acknowledgments are devoted to colleagues or technicians. Some journals place acknowledgments as footnotes of the paper, so consult the guidelines of the journal.

### 3.3.2.7. *References*

Citations of published literature should follow the instructions set by the journal (or institution) to which the manuscript is going to be submitted. You should carefully check that all references in the text are listed and that all references listed are in the text. The mostly used system of providing references in the text is the “authors-year” system. The reference can participate in the sentence or come at the end of the sentence. The following is an example: “The value of the euro has increased above the American dollar (Bush, 2008),” or “Bush (2008) mentioned that the value of the euro has increased over the American dollar.” Depending on the referencing system, but in many cases, if more than two authors are to be mentioned, the first author is given followed by “et al.” (e.g., (Bush et al. 2008) or (Bush et al. (2008)).

Information on the reference list itself is given in Section 5.2.

### 3.3.2.8. *Appendix*

The appendix provides readers with supplementary material that may not be essential to the understanding of the paper but may be helpful. Such material may include numerical examples (which may instead be included in the text, depending on the nature of the paper), questionnaires, and extensive details of analytical procedures, novel computer programs, or derivations of complex mathematical formulas or proofs. Alternatively, supplementary material may be provided on request from the corresponding author or on a website; make sure the address of the author or the website is available.

Using open access journals (see Section 7.4.1.), the possibility of adding one or more (eventually long) appendices is now available.

### 3.3.2.9. *Preface in theses*

A preface is only used for theses and books, not for scientific articles. Because a preface has nothing to do with the content of the document, it is put on a separate page before the content.

Try to write an original text. It should describe the relation between the writer of the document and all those (persons, institutes, etc.) who helped him. Try to arrange them in the order of importance.

### 3.3.2.10. *Table of content in theses*

In theses and books, the content comes at the beginning, after the preface. The page numbering starts usually after the page with the content. The pages before the content can be numbered by Roman numbers. However, other systems also exist with the numbering from the very beginning. If a document consists of more than one part, the numbering continues from one part to the other.

In the content, no words are underlined, but one strives to make the clear overview of the different chapters.

### 3.3.2.11. *Copyright*

Especially in theses, the author and the promoter might protect their document by a statement on copyright: At Wageningen University & Research (NL) as well at other universities the following text is often used: "The author and the promoter give the permission to use this thesis for consultation and to copy parts of it for personal use. Every other use is subject to the copyright laws, more specifically the source must be extensively specified when using results from this thesis."

Close with your name, the name of the promoter, date, and signature. It is eventually useful to write the text in English and the local language.

## 3.4. Scientific versus popular science writing

There are different communication channels, some with a more popular character and some with a more research character. Examples of the more "extension and popular" type of documents



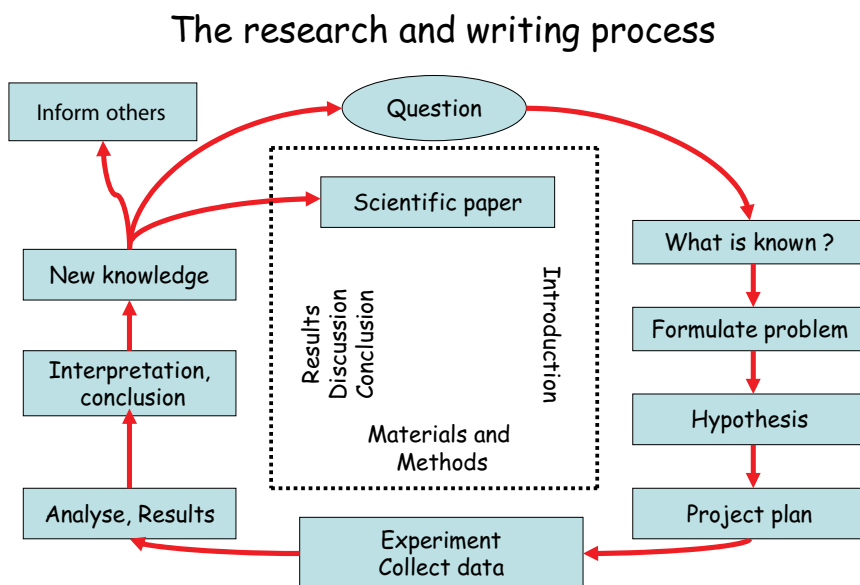
are extension manuals, newspaper reports, magazine articles, radiobroadcasts, films and video, practical demonstrations, cartoons, and photographs. Research documents can be research journals, research reviews, conference papers, theses, book chapters, annual reports, newsletters, project proposals, lectures, leaflets, and posters.

Scientific writing always follows the structure of the research. As can be seen in **Figure 1**, the different parts of a scientific paper (inner part) correspond to a certain step of the research. Within the different chapters there can be a different structure. Items can be put in chronological order, order of interest/importance, by cause and effect, or by comparison/contrast.

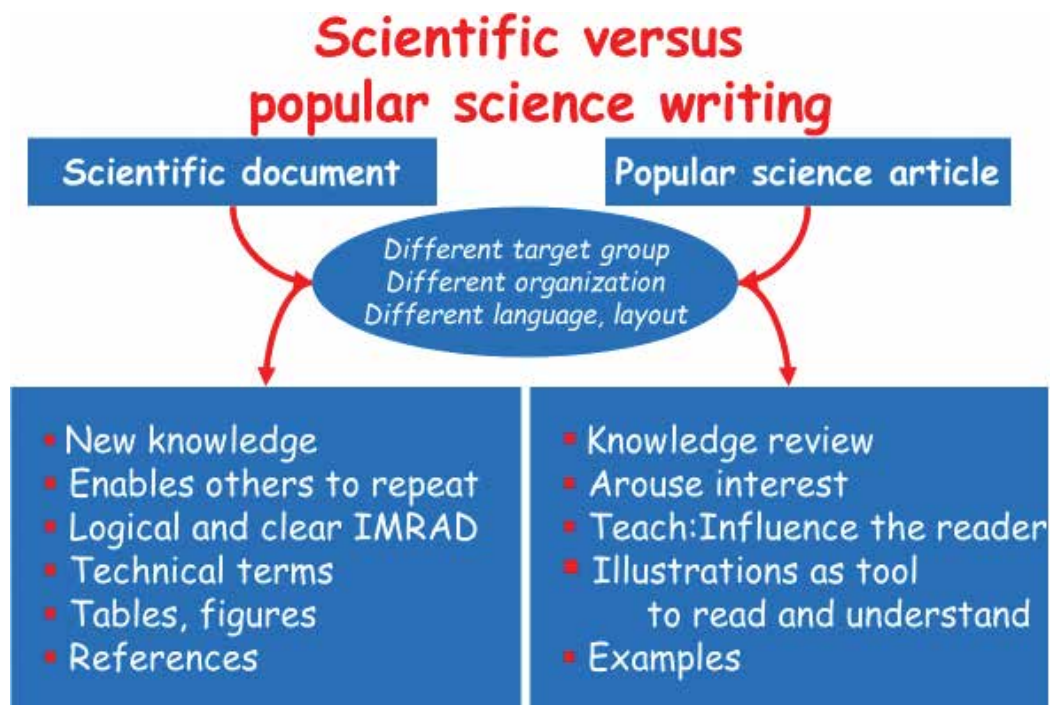
Anyway, scientific communication is linked to a delivery aspect and a receiving aspect. The delivery should be accurate, brief, and clear, while the receiving part should be in a way that it is easy to understand and adaptable to the audience.

To be very effective in writing, you should, before starting the writing, ask yourself *to whom*, *why*, *what*, and *how* are you going to write. About the “to whom,” you should consider: specialists, a wider group, students, etc.; the “why” refers to just for merit, to add to the knowledge, to teach, to inform, to persuade, etc.; the “what” refers to the message, review, expectations, questions, etc.; and the “how” refers to the satisfaction of the need of the audience.

Nowadays, scientists are of course responsible for the communication with the scientific world, but, more and more, also for communication of the findings to the public. We call this popular science writing. Because the audience is different, a different presentation should be followed. The scientist should write at the level of the readers’ knowledge and experience, with not many details, but accurate, brief, and clear. A lot of attention should be paid to an attractive title, visuals, and a clear layout. In **Figure 2**, a summary is given of the most striking differences between scientific and popular scientific writing.



**Figure 1.** Link of the research process with the writing structure (after Malmfors et al., 2002).



**Figure 2.** Differences between a scientific paper and a popular science article (after Malmfors et al., 2002).

## 4. Tables, figures, and other illustrations

This part gives instructions on how to prepare and locate tables, figures, diagrams, or illustrations in a scientific paper or other document. Tables and figures are used to present the results of experiments. When referring to a figure in the text, the word “Figure” is usually abbreviated as “Fig.,” while “Table” is not abbreviated. Both words are spelled out completely in descriptive legends.

Figures and tables are numbered independently, in sequence with their appearances in the text, starting with **Figure 1** and **Table 1** in each chapter (e.g., **Figure 1** or **Table 4**). If, in revision, you change the presentation sequence of the figures and tables, you must renumber them to reflect the new sequence.

In manuscripts, ready to be submitted to an editor, tables and figures are usually put on pages separated from the text material. In the text, each table or figure should be placed as close as possible to its announcement, but never before. For fluency reasons, illustrative material is sometimes put at the end of the results section. However, if possible, figures and tables should be within the text.

Any table or figure you present must be sufficiently clear, well-labeled, and described by its legend to be understood by the reader without consulting the results section, i.e., it must be able to stand alone and be interpretable.

#### 4.1. Tables

A table is used for a set of data. However, if you can bring a table or part of it into words, it is preferable to do so. The title is always given “**above**” the table and contains all information to understand the table **independently** without referring to the text. Additional comments can be put below the table as a note. It is better to number the notes with a letter than with figures, e.g., 5<sup>a</sup> or 5<sup>2</sup> (square?). No full stop is put at the end of the title. The title and information in the heading of the table or in the main body or in the notes are typed by single spacing. Use in the heading of the table only known abbreviations and SI units. Avoid many zeros, hundreds, plusses, or minuses. Do not use more significant numbers than necessary to avoid a false impression of precision. Constant figures do not come in the table; reference to them is made in the title. Take the following information into consideration:

-	Missing observation
0	Zero
blank	There cannot be any figure

If a table is presented vertically on the right page, the title is placed toward the middle of the book. If the table is put vertically on the left page, then the bottom of the table is near the middle. Vertical lines are not necessary.

There are two variables in a table:

- The independent variable—the one which is fixed by the author;
- The dependent variable—the one which is measured.

Depending on the number of independent variables there are one-, two-, three-, or four-dimensional (4D) tables. In each of them the number of dependent variables can be one or more.

#### Examples

*The content of the presented tables is fictional; they only serve as an example for layout.*

##### *One-dimensional table*

$$x = f(a); y = f(a)$$

For example: **Tables 1–3.**

**Table 1.** Evolution between 2002 and 2014 of the market<sup>a</sup> of apples and grapes in Utopia (thousand tons) (own design).

Activities	2002	2004	2006	2008	2010	2012	2014
Production							
Export							
Import							
Total available amount							
Used for feeding							
Losses							
Processing for wine							
Consumption							

Note: <sup>a</sup>Including canned and dried output, calculated as fresh products.

**Table example 1.**

Some tables can also be shown as a line graph. Note also that the data in a column can be aligned to the left, the right or put in the center of a column. The information in the head of the table can be put in bold or in a normal font.

**Two-dimensional table**

$$x = f(a, b); y = f(a, b)$$

For example: **Table 4.**

The  $x$  and  $y$  are only mentioned in the title.

The data of these tables can also be put in a diagram.

**Three-dimensional table**

$$x = f(a, b, c); y = f(a, b, c)$$

**Table 2.** The basic units of the SI system.

Physical quantity	Name of unit	Symbol for unit
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

**Table example 2.**

**Table 3.** The influence of farm size on the income and profit of agricultural companies in Utopia (own design).

Activities	Size of farm (ha)		
	<500	501–1000	>1000
Number of companies per size group			
average size per group (ha)			
Income, thousand euro:			
- per company			
- per 100 ha agricultural land			
Net profit (+) or loss (-) (thousand euro)			
- per company			
- per 100 ha agricultural land			

**Table example 3.**

For example: **Tables 5** and **6**. Depending on the emphasis (either more focus on light, or on moisture), the layout of the table can be changed.

The x and y are only mentioned in the title.

A different possibility of layout can be used.

#### **Four-dimensional table**

$$x = f(a,b,c,d); y = f(a,b,c,d)$$

For example: **Table 7**.

The x and y are only mentioned in the title.

**Table 4.** Annual average ( $n = 6$ ) and standard error of  $N_2O$  and  $CO_2$  fluxes for NT, RT, and CT (RT = reduced tillage, NT = no tillage, and CT = conventional tillage) in 2007 and 2008; statistical differences ( $P < 0.05$ ) between 2007 and 2008 are indicated by capitals and statistical differences ( $P < 0.05$ ) between treatments within 1 year are indicated by small letters (own design).

	NT	RT	CT
kg $N_2O$ -N ha <sup>-1</sup>			
2007 (1 yr)	4.6a, A ± 0.7	3.8a, A ± 0.4	3.3a, A ± 0.5
2008 (1 yr)	1.0a, B ± 0.2	0.9a, B ± 0.2	1.3a, B ± 0.7
ton $CO_2$ -C ha <sup>-1</sup>			
2007 (1 yr)	4.6a, A ± 0.3	5.0a, A ± 0.3	5.0a, A ± 0.7
2008 (1 yr)	5.0a, A ± 0.2	5.1a, A ± 0.2	6.7b, B ± 0.7

**Table example 4.**

**Table 5.** Influence of light intensity, moisture content, and temperature on the growth (mm) of tomato seedlings within 48 hours (own design).

Light intensity ( $\mu\text{E m}^{-2} \text{s}^{-1}$ )	Moisture content (% R.H.) <sup>a</sup>	Temperature (°C)			
		10	20	30	40
500	60	0	2	3	2
	90	1	5	7	3
1000	60	0	8	10	3
	90	2	10	12	5
1500	60	2	15	16	6
	90	4	17	20	8

Note: <sup>a</sup>R.H. = Relative humidity.

**Table example 5.**

**Table 6.** Influence of moisture content, light intensity and temperature on the growth (mm) of tomato seedlings within 48 hours (own design).

Moisture content (% R.H.) <sup>a</sup>	Light intensity ( $\mu\text{E m}^{-2} \text{s}^{-1}$ )	Temperature (°C)			
		10	20	30	40
60	500	0	2	3	2
90		1	5	7	3
60	1000	0	8	10	3
90		2	10	12	5
60	1500	2	15	16	6
90		4	17	20	8

Note: <sup>a</sup>R.H. = Relative humidity.

**Table example 6.**

4.2. Figures

Figures are visual presentations of results. There are different possibilities such as graphs, bars, diagrams, pictures, schemes, maps, etc. Examples of the different types of figures are included at the end of this section. Graphs mainly show trends or patterns of relationships; tables are mainly used to give exact data. Sometimes also in figures, exact data are given as well.

The main purpose of figures is to show a certain trend, a prognosis or an extrapolation. The title is always given **below** the illustration and starts with “Fig.”. No full stop is put at the end of the title.

When no clear trend is present or when exact figures must be given, it is better to use tables. In some cases, a figure is better than a table (see Special remarks). For comparison of different series of data, however, figures are very useful. To differentiate series of data, different types of lines and symbols can be used. They can eventually be colored. The most useful ones are ●, ○, ▲, ▼, ■, □. Little crosses or plusses are less useful. Several software programs

**Table 7.** Growth (mm) of oil palm seedlings as a function of two nitrogen fertilizer levels, 0 and 100 kg N ha<sup>-1</sup>, three temperatures 20, 30, and 40°C, two moisture contents 60 and 80% R. H., and two light intensities 500 μE m<sup>-2</sup> s<sup>-1</sup> (I) and 1500 μE m<sup>-2</sup> s<sup>-1</sup> (II) (own design).

N-fertilization (kg N ha <sup>-1</sup> )	Temperature (°C)	60% R. H. <sup>a</sup>		80% R. H.	
		I	II	I	II
0	20	2	15	5	17
	30	3	16	7	20
	40	2	6	3	8
100	20	4	28	7	34
	30	8	32	15	39
	40	7	16	7	15

Note: <sup>a</sup>R.H. = Relative humidity.

**Table example 7.**

(Excel, sigmaplot, etc.) are available for making all kinds of figures. The use of error bars is illustrated by the figures in Section “Special remarks.” The calculation of the uncertainty of the slope of a line is shown in section “Special remarks.” Definitions of the symbols and lines can be put in an empty part of the figure, or in the title. To call attention to specific information on pictures, arrows or little letters can be added to it.

When an illustration is copied from another reference, mention at the end of the title, between brackets, e.g., (from Jackson, 1982). When the illustration is redrawn or when the information is rearranged, write, e.g., (after Jackson, 1982).

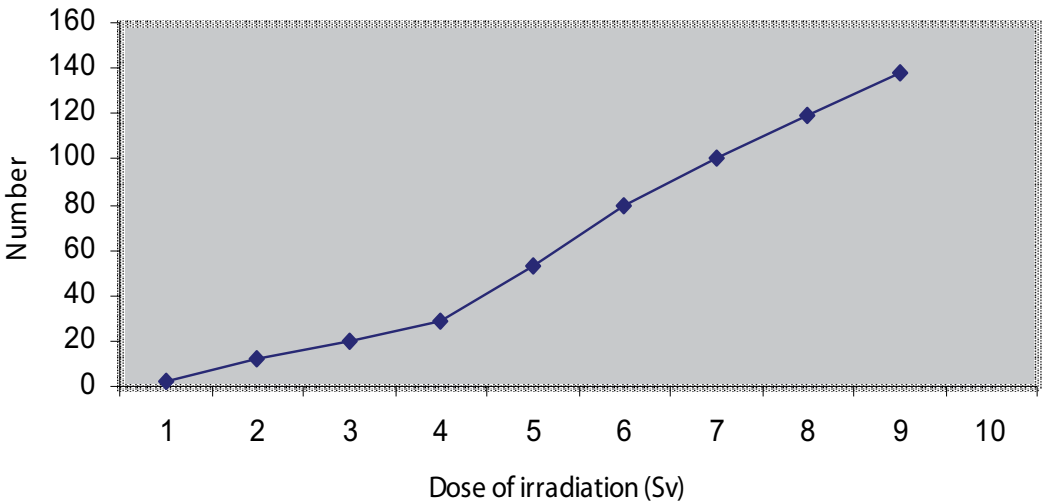
There are different kinds of figures: line graphs, surface graphs, bar diagram or histogram, bar group diagram or component bar diagram, pie chart diagram, pole diagram, flow chart, triangle diagram, cartogram, and scheme.

## Examples

### 4.2.1. Line graph

A line graph gives the relation between the independent variable ( $x$ -axis) and the dependent variable ( $y$ -axis) of observations on one object (**Figure 3**). Time is always set on the  $x$ -axis. Usually, the origin of both  $x$  and  $y$  axes starts at 0. This is not necessarily the case for big numbers: either a broken axis can be used or the axes can start at any other number than zero (see example in Section “Special remarks”). It is not nice to see a curve in one or another edge of the graph. Try to have the curve over the full graph; if necessary adjust the scale (**Figures 3–6**)

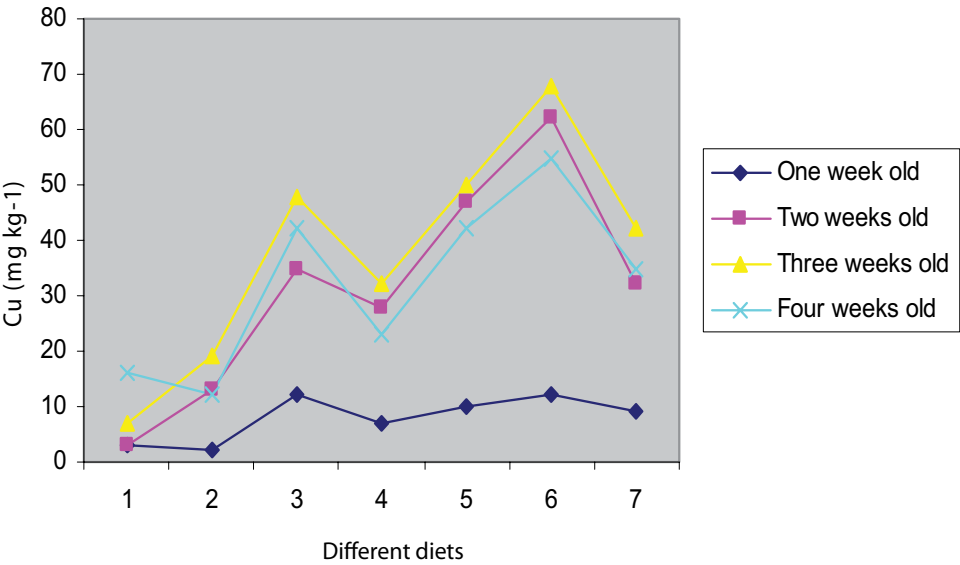
Do not draw the abscissa and ordinate too long. If you have data varying between 0 and 58, then finish the axis at 60. If different observations are far from each other or irregularly spread in a graph, they should be connected with straight lines. The use of smooth regression curves, however, often increases the clearness of the figure and data interpretation. Put along the axes numbers on an equal distance; but not every dash needs to have an according number.



**Figure 3.** Number of sick people as a function of exposure to irradiation (own design).

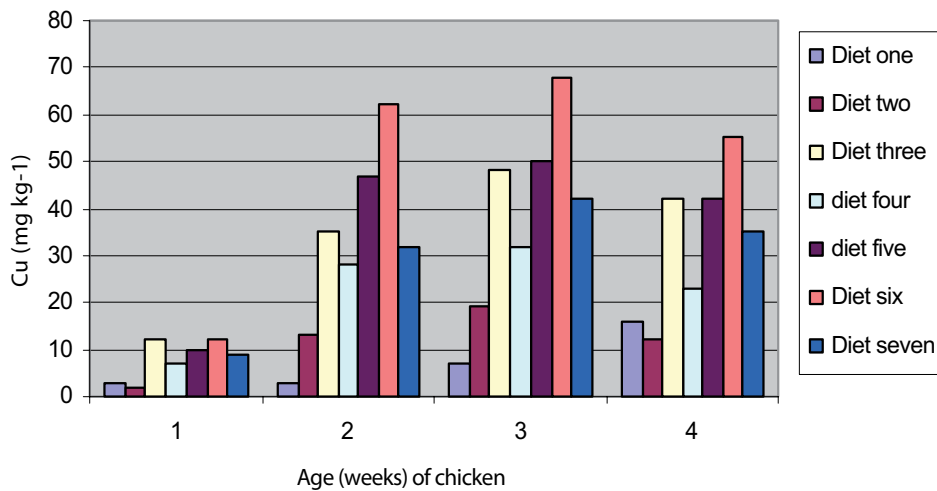
In logarithmic diagrams one or both axes are not arithmetic but logarithmic. A logarithmic scale is especially good for comparison of ratios. Growth observations can be easily visualized with a semi-logarithmic diagram.

A function of three variables can be drawn in a three-dimensional graph. However, it is difficult to accurately see the exact values of the data. The use of auxiliary lines can partly solve this problem, although the total figure will become somewhat heavy. Avoid having lines in the back lower than lines in the front. The direction of the z-axis can, if necessary, be changed.



**Figure 4.** Copper content ( $\text{mg kg}^{-1}$ ) in the liver of chicken (1–4 weeks old) with seven different diets (own design). *A line graph is not correct. The data between the diets is not continuous.*



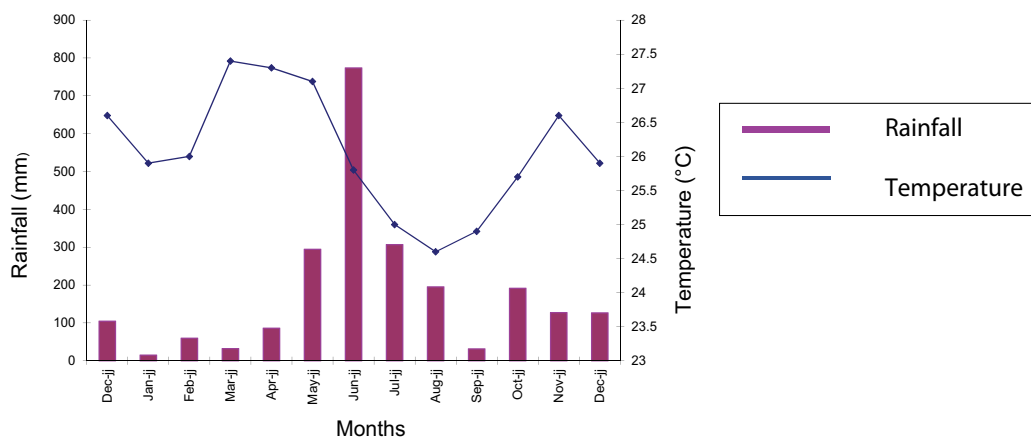


**Figure 5.** Copper content ( $\text{mg kg}^{-1}$ ) in the liver of chicken (1–4 weeks old) with seven different diets (own design). A bar diagram is correct.

Discontinuous information cannot be shown by line graphs; therefore, you should use bar graphs. In **Figure 4**, different diets are compared. The figure gives the impression that there are also diets between e.g., 3 and 4, which are not true; therefore, a bar group diagram should be used (**Figure 5**). See also part of **Figure 6**.

#### 4.2.2. Surface graph

Accumulation of dependent variables leads to surface graphs. To distinguish the different variables, the surfaces can be differently colored or filled up. If different surfaces are combined, it is common to have the smallest surface near the  $x$ -axis, and above the first surface the next ones in the order of increasing surfaces (**Figure 7**)



**Figure 6.** Distribution of rainfall and temperature in Utopia (own design) (note: a combination of continuous and discontinuous data).

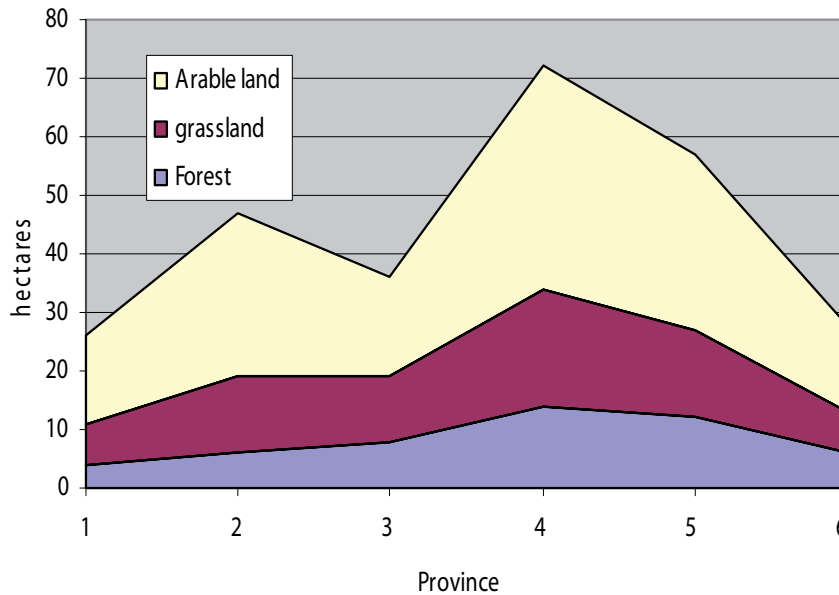


Figure 7. Example of a surface diagram (own design).

#### 4.2.3. Bar diagram or histogram

When similar observations are carried out not on one object, but on many similar objects, the use of bar diagrams or histograms is advisable. For example, measurement of plant growth (roots + stems) as a function of time cannot be carried out on the same plant. A line graph with a swarm of points can also be used (Figures 6, 8, and 9). For construction of a histogram, the following rules need to be taken into consideration:

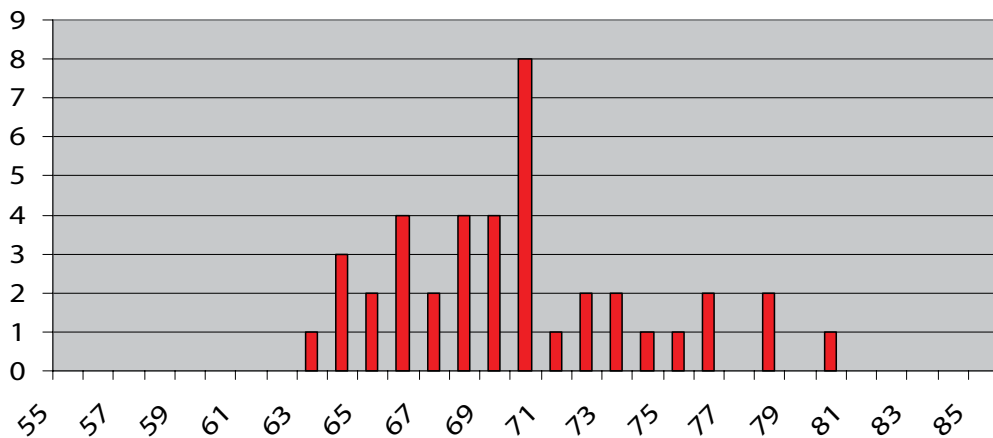
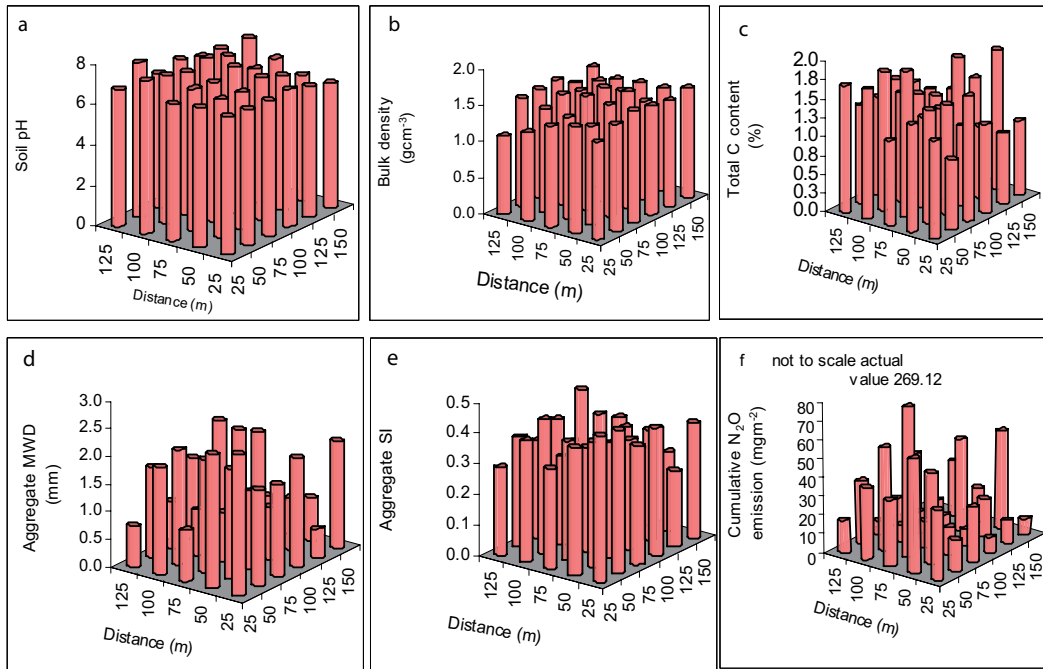


Figure 8. Age distribution of the members of the chemical society (own design).

- The  $y$ -axis practically always starts at zero.
- All bars are equally wide.
- A bar cannot be interrupted.



**Figure 9.** Histogram (3D) showing the spatial distribution of soil pH (a), bulk density (b), organic C (c), aggregate mean weight diameter (d), aggregate stability index (e) and  $\text{N}_2\text{O}$  emission for the whole incubation period, and (f) on a  $25 \times 25 \text{ m}^2$  grid, 0–50 m = RT, 50–100 m = NT, and 100–150 m = HT in z axis (own design).

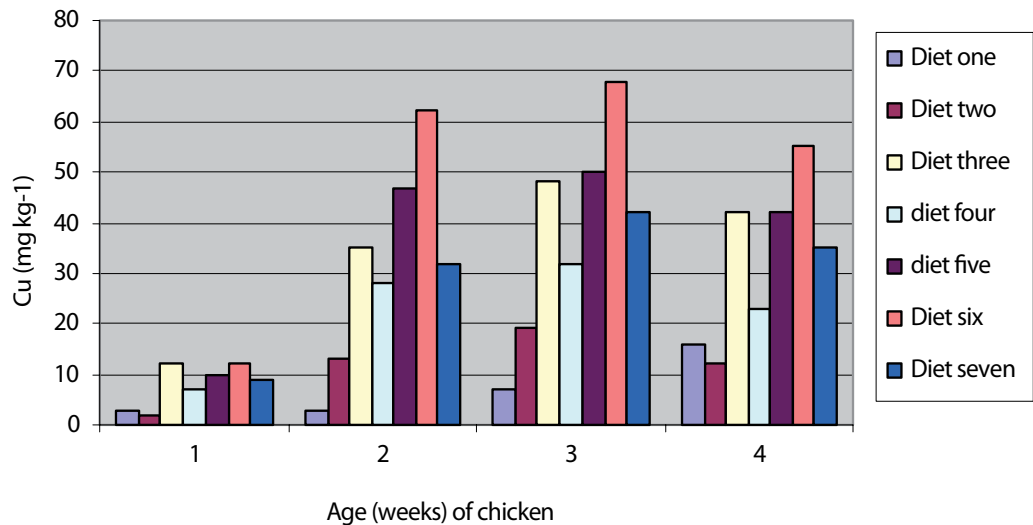
In a bar diagram, the bars are apart from each other. The distance between the bars is, e.g., half of the bar width. In a histogram, bars are joint together. A three-dimensional presentation is also possible.

Use a bar chart to compare one item with another. You must show bars in a logical (chronological) order and add a label either inside or outside (not both). Unless necessary you should avoid 3D bar charts and composite bars.

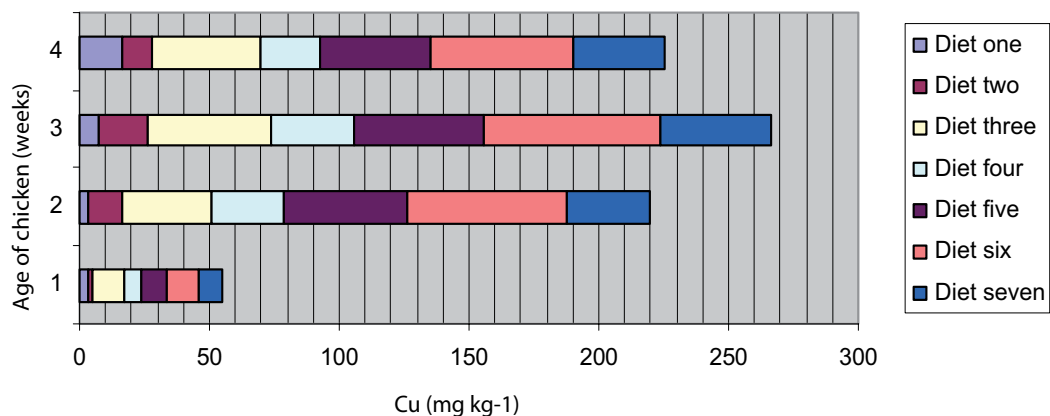
#### 4.2.4. Bar group diagram and component bar diagram

If several bar diagrams have the same independent factor, you can group them together (**Figures 5, 10, and 11**). You must consider the following:

- Preferably, do not group more than three bars.
- Keep a distance of at least one bar between each group.



**Figure 10.** Copper content ( $\text{mg kg}^{-1}$ ) in the liver of chicken (1–4 weeks old) with seven different diets (own design).

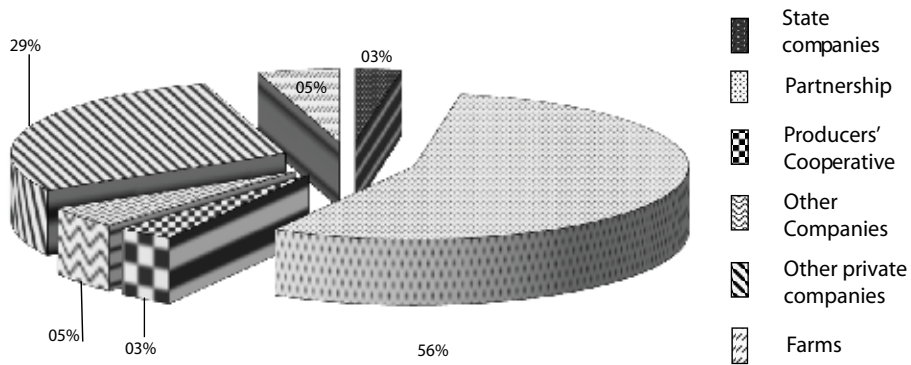


**Figure 11.** Copper content ( $\text{mg kg}^{-1}$ ) in the liver of chicken (1–4 weeks old) with seven different diets (own design).

In a component bar diagram, the dependent variables with the same independent variables are shown in one rectangle. As such, the subdivision of one unit can be visualized. The different parts can be differently marked.

#### 4.2.5. Pie chart diagram

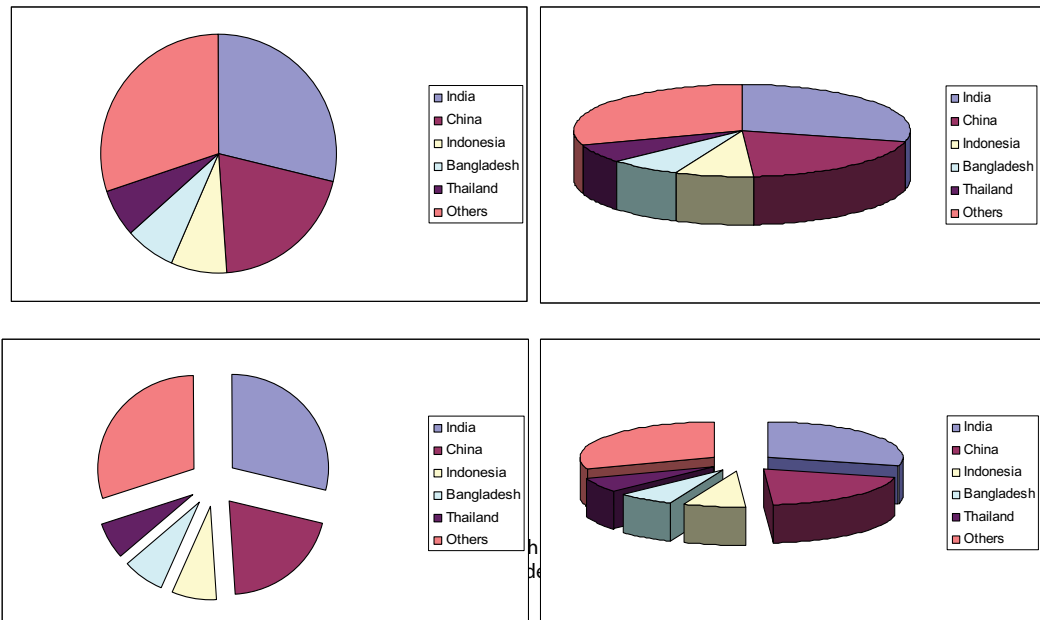
In a pie chart diagram, the total amount is given by the total surface of the pie. Parts of that total amount can be given by circle segments (**Figures 12–14**). The disadvantage of such a figure is that it is difficult to compare the different parts.



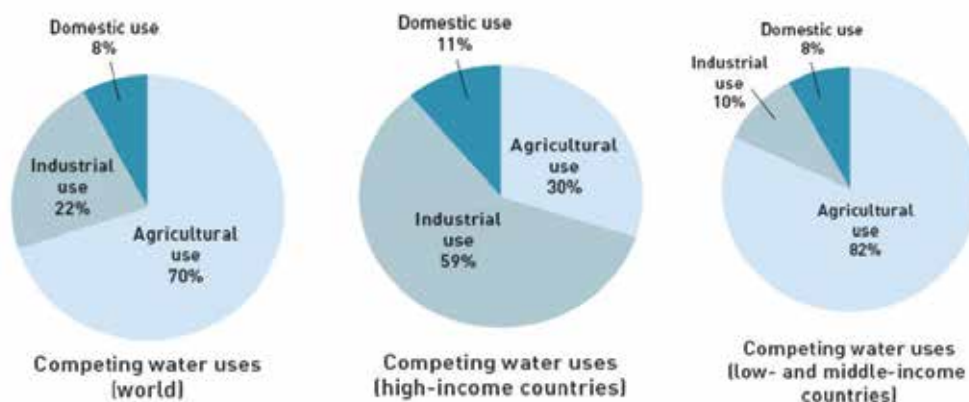
**Figure 12.** Different types of companies and their economic importance in Utopia (own design).

The basic rules for construction of a pie chart diagram are as follows:

- Use a pie chart diagram to compare a part to the whole.
- Usually start at 12:00 with the largest segment.
- Limit segment to 5–7.
- Labeling of segments occurs mainly outside the circle.



**Figure 13.** Different examples of pie charts related to the relative importance of a group of different countries (own design). (note: it is advisable to add the percent value of each segment either after the country name or outside or inside the segment).



**Figure 14.** Percent distribution of water use among domestic use, industrial use, and agricultural use in the world, in high-income countries and in low- and middle-income countries.

#### 4.2.6. Flow diagram

To show the route of different products in an overall production process, a flow diagram can be drawn (**Figures 15–17**). A flow scheme in a discussion or a flow scheme in a biological process can be shown in a flow diagram as well. The width of the route can be a measure for the importance of the flow.

#### 4.2.7. Cartogram

The combination of a geographical map and a diagram leads to a cartogram (**Figure 18**). The magnitude of a certain event in a certain region can eventually be visualized by different symbols.

#### 4.2.8. Triangle diagram

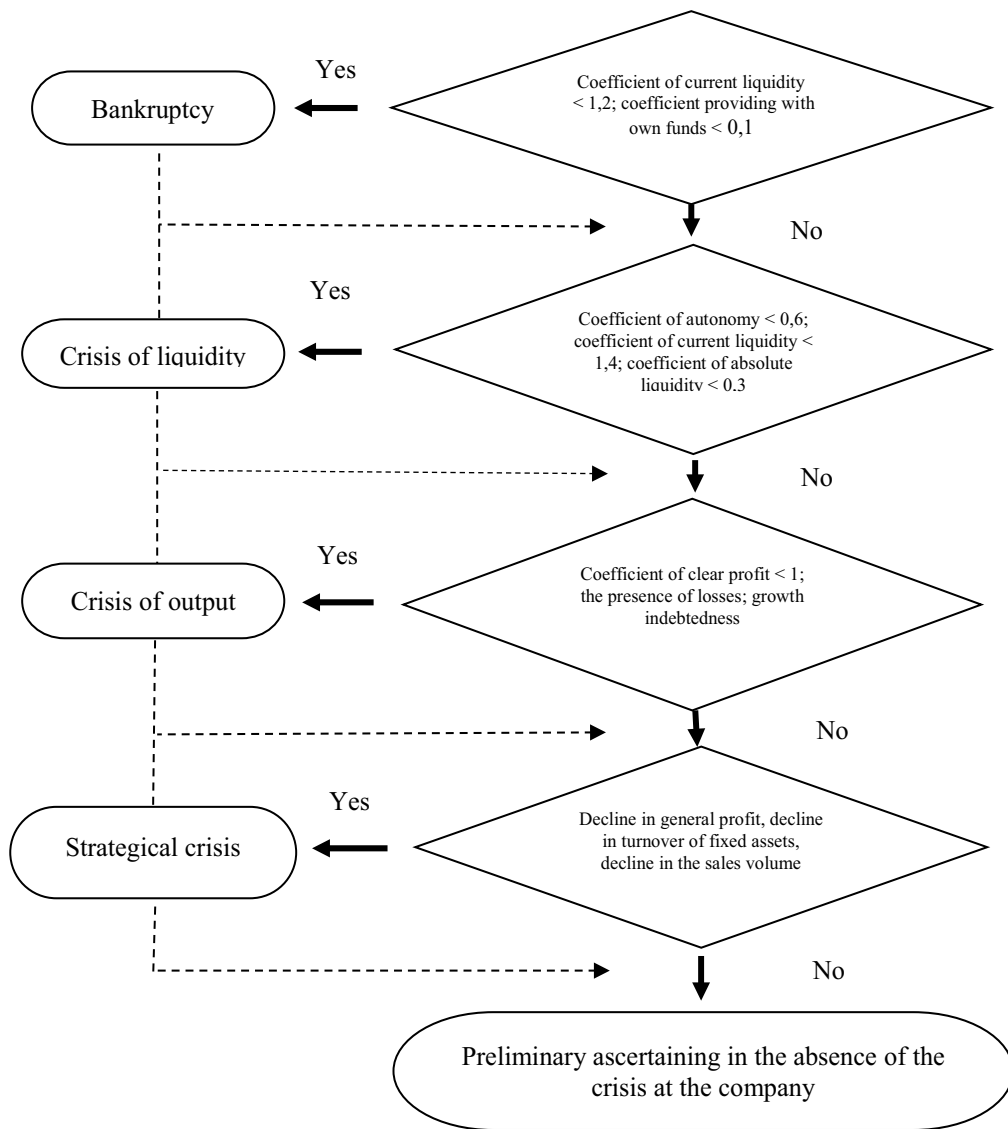
A triangle diagram is an equilateral triangle of which each side is subdivided from 0 to 100. Each side represents an independent variable (**Figure 19**). The sum of the three must be 100%.

#### 4.2.9. Scheme

In drawings of constructions or in a schematic presentation of experimental setups, the hierarchy of the data must be respected (**Figure 20**). Therefore, letters of different size can be used. If possible, the whole drawing is put within a frame.

#### 4.2.10. Pole diagram

A pole diagram is a line graph or a bar diagram put on a circle, of which the circumference is the independent variable and the radius the dependent variable (**Figure 21**).

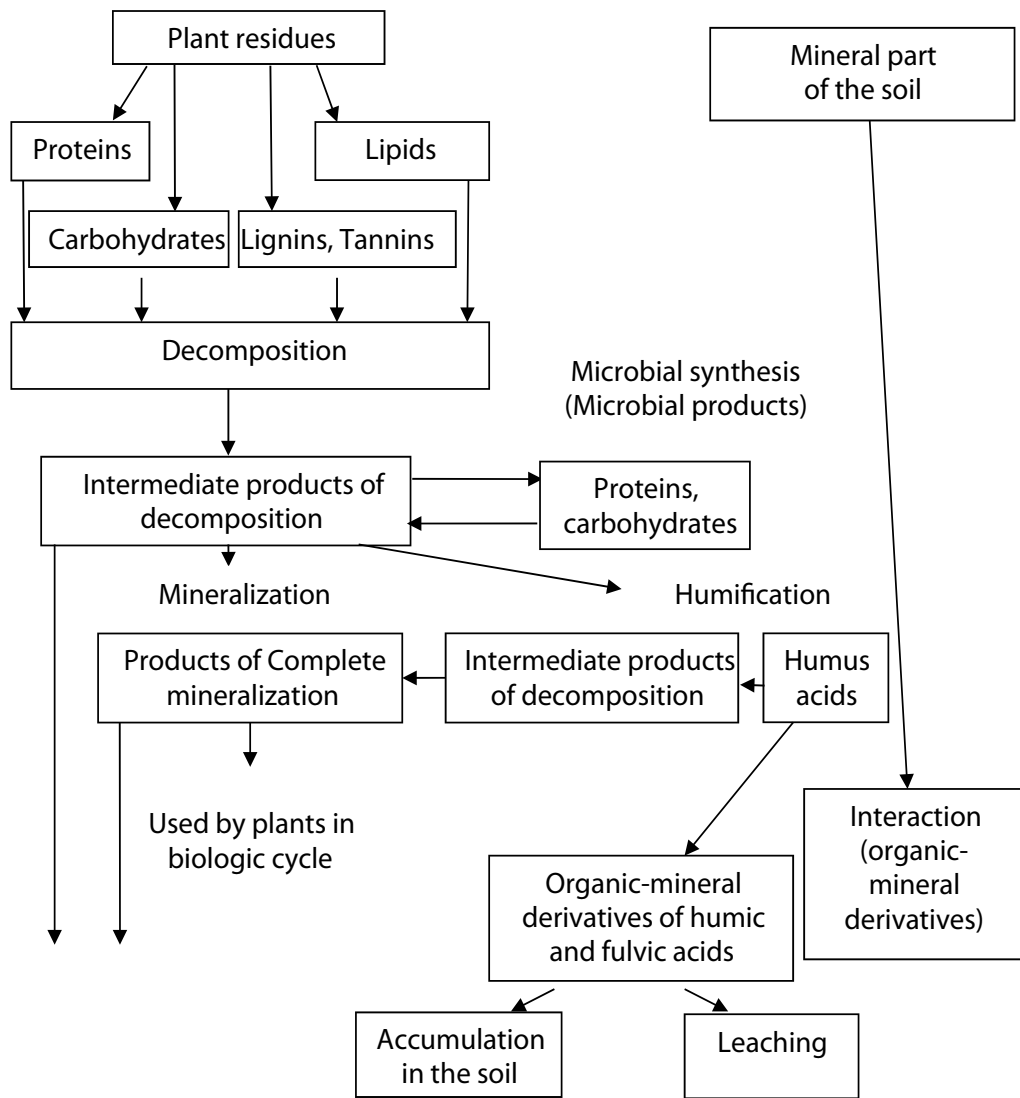


**Figure 15.** Algorithm of diagnosis of the crisis process phase in a company (own design).

#### 4.3. Special remarks (after Pentz and Shott [58])

When to use a table or a figure? It depends on the function both have. Tables are mainly used for exact data, while figures show trends. When you draw a table, make also a figure and compare. Use a proper choice of scale, considering the precision of reading; tiny dots can be confused with dirt on the paper, while big dots give loss of precision.

In most cases, a smooth curve is more appropriate than a curve whereby points are connected by straight lines. It depends on the circumstances (**Figure 22**).



**Figure 16.** General scheme of soil humus formation (after I.V. Tyurin (1965). Soil Organic Matter and its Role in Fertility. Nauka, Moscow [in Russian]).

Error bars can learn a lot. If results deviate from a smooth curve by much more than the error bar, the errors are underestimated, or the results should not be described by a smooth curve. Overestimation is also possible when the results deviate from the smooth curve by much less than the error bars. If one point does not fit the line, one should be careful in deciding towards a mistake. It can be an anomaly in the experiment.

To estimate the uncertainty of a slope, one can draw lines passing through all the error bars with the maximum and minimum possible slopes and calculate the average difference between their slopes and the slope of the straight line best fitting the results.



#### 4.4. Formulas and units

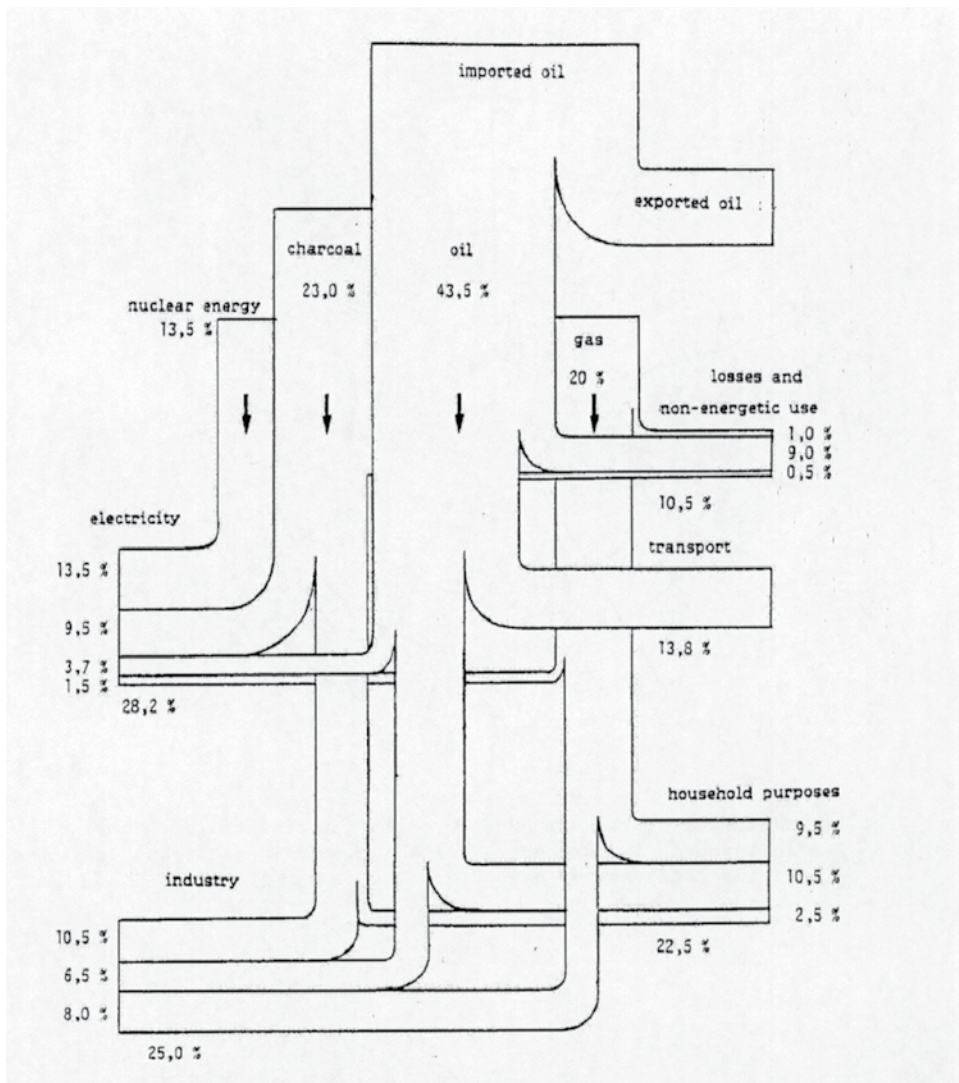
After each formula, the used symbols must be explained as in the following example:

$$p = F/A \text{ or } p = F A^{-1}$$

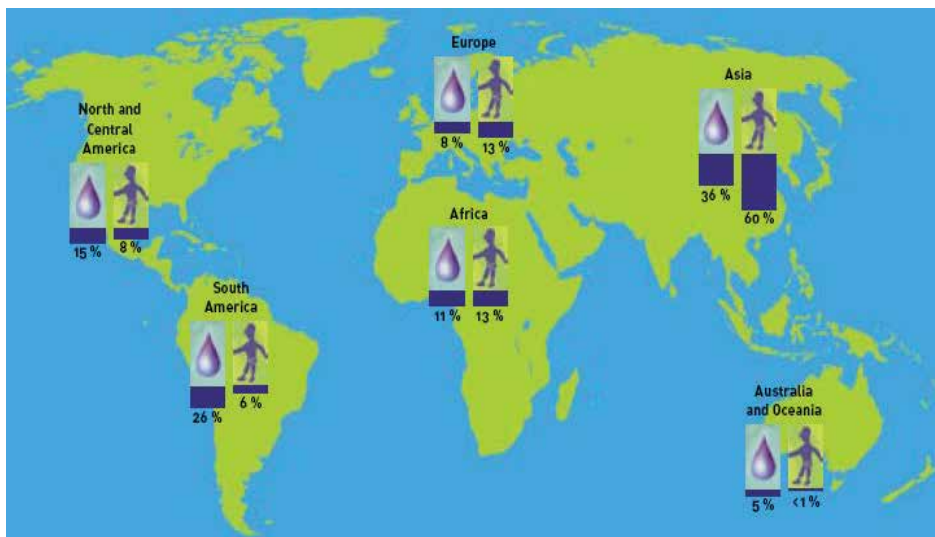
therein  $p$  = pressure (PA)

$F$  = force (N)

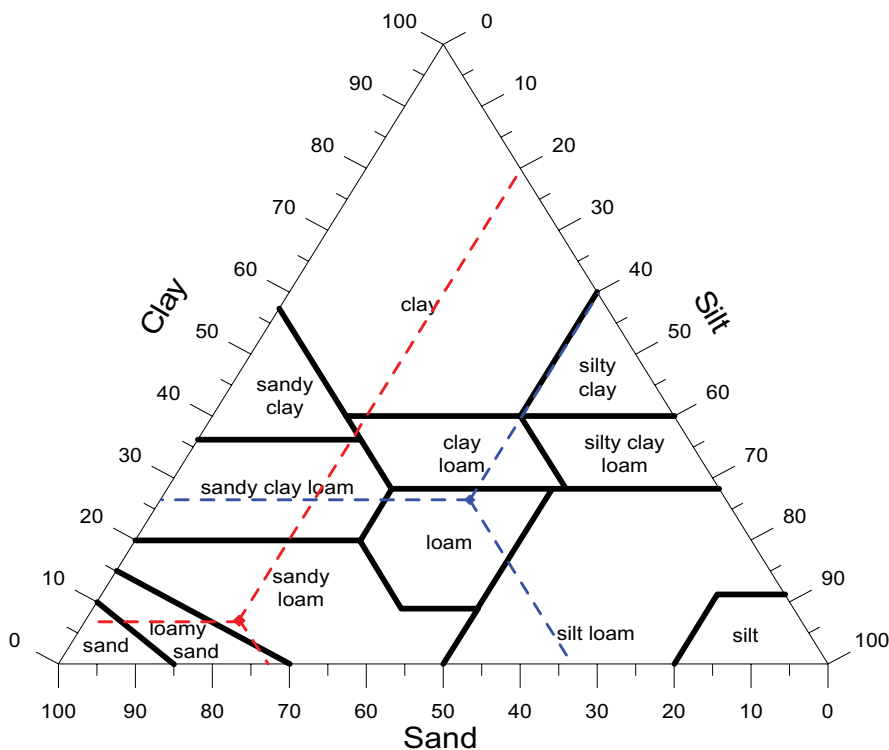
$A$  = surface ( $m^2$ )



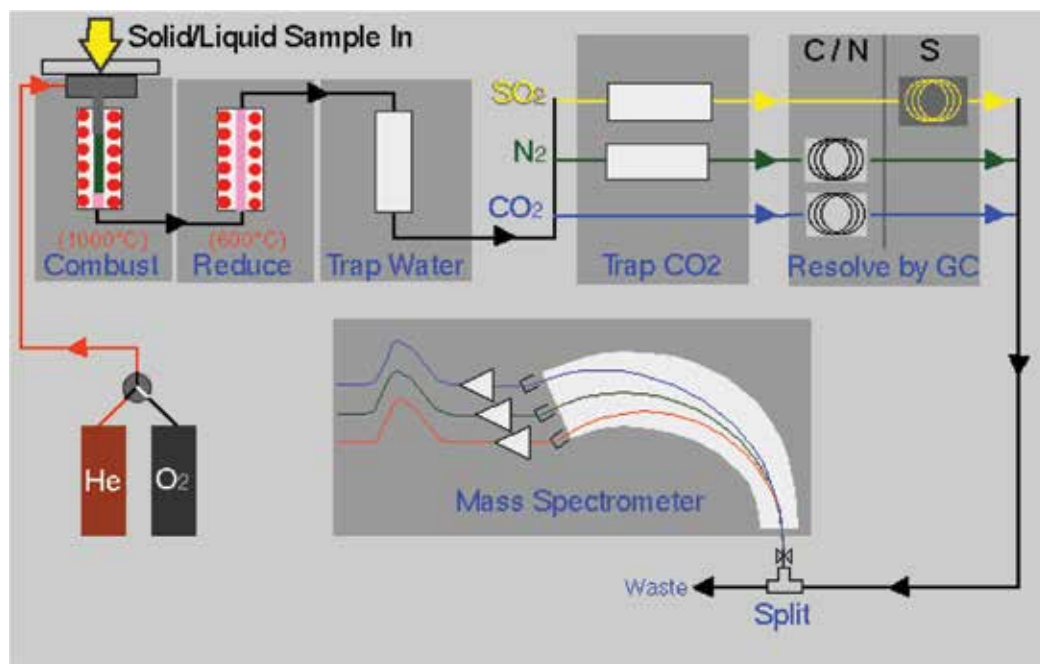
**Figure 17.** Consumption of fuel in Utopia in 2008 (after M. Potemans (1986). VGB Kraftwerkstechnik, 66, 1015-1021).



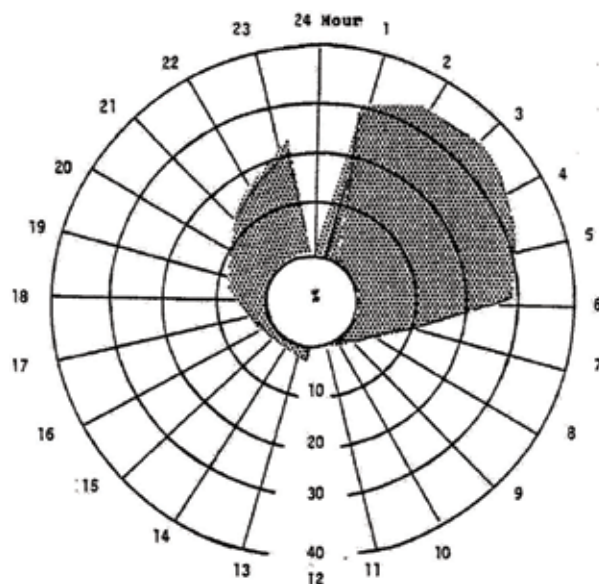
**Figure 18.** Survey of the distribution of world population and available drinking water among the different countries (after Melnychuk [53]).



**Figure 19.** Soil texture triangle (see sandy loam texture (7% clay, 0–2  $\mu\text{m}$ ; 20% silt, 2–50  $\mu\text{m}$ ; 73% >50  $\mu\text{m}$ , sand) and loam texture (26.5% clay, 0–2  $\mu\text{m}$ ; 40.2% silt, 2–50  $\mu\text{m}$ ; and 33.3% >50  $\mu\text{m}$ , sand)) (own design).



**Figure 20.** Example of a scheme of He and O<sub>2</sub> flow in a chemical analysis (own design).



**Figure 21.** Evolution of the mean number (shadowed area) of car accidents during 1 day (24 hours), influenced by alcohol abuse and expressed as percentage of the total number of accidents (own design).

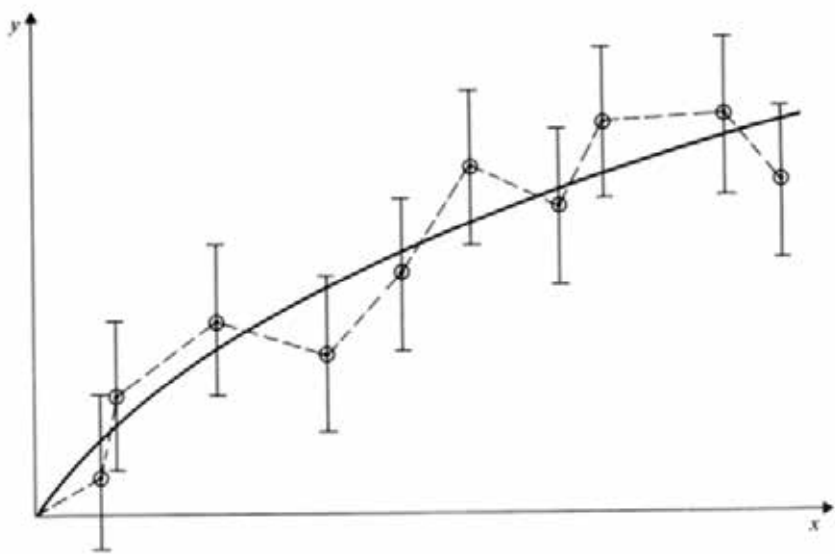


Figure 22. Two ways of drawing the “best curve” through a set of points; which of the two depends on the circumstances [58].

Table 8. SI prefixes.

Fraction	Prefix	Symbol	Fraction	Prefix	Symbol
$10^{-1}$	deci	d	10	deka	da
$10^{-2}$	centi	c	$10^2$	hecto	h
$10^{-3}$	milli	m	$10^3$	kilo	k
$10^{-6}$	micro	$\mu$	$10^6$	mega	M
$10^{-9}$	nano	n	$10^9$	giga	G
$10^{-12}$	pico	p	$10^{12}$	tera	T
$10^{-15}$	femto	f	$10^{15}$	peta	P
$10^{-18}$	atto	a	$10^{18}$	exa	E

Table example 8.

Take the following guidelines into consideration:

- Be consistent with open spaces in formulas and do not put a dot behind the formula.
- Avoid letters which can easily be confused with numbers, e.g., 0 and 1.
- Use the correct SI prefixes (Table 8).
- A time indication is given by h.
- The abbreviation for gram is g (not gr).

Hectare is ha (not Ha)

Second is s (not sec)

Temperature is t

Absolute temperature is T

Cubic centimeter is cm<sup>3</sup> (not cc)

- Never start a sentence with a figure and avoid confusions as 5 (five) 100 mL beakers.

## 5. References in the text and the list

### 5.1. References in the text

In the introduction of a scientific document, it is normal to present the state-of-the-art knowledge on the treated subject. Also books and theses can contain a chapter with a literature overview. Therefore, recent and relevant references are used. Sometimes, it can be necessary to refer to somewhat older references if they are basic and if they are necessary to understand the content of the document. Next to the introduction, it is, however, practically always necessary to also refer to some literature in the different parts of a scientific paper, book, or thesis.

To quote references in a document, the “name-year” system is widely accepted. It consists of the name of the author and the year of publication. Name and year must be put between brackets if they do not take part in the sentence. In case a reference is part of a sentence, only the year is put between brackets, after the name(s) of the author(s). A citation from the Internet is always put between brackets. If a source has more than two authors only, the first one is mentioned followed by “et al.” (and others). If several references are added one after another, they should be arranged in alphabetical order or chronologically (old to young). References of the same author with the same year can be distinguished by adding a small letter a, b, c, etc.

#### Examples

- According to some authors (Bougoul et al., 2005; Dolan, 2002b; Husman, 2001), hydraulic conductivity and water content depends on the substrate suction ...
- According to some authors (Husman, 2001; Dolan, 2002b; Bougoul et al., 2005), hydraulic conductivity and water content depends on the substrate suction ...
- A similar approach had been supported by Baskin (2002), Pluimers et al. (2000), and Farina (2002a).
- Genetic drift in aphid populations is usually intensified by regular plant protection treatments (<http://.....>, consulted on [date]).

### 5.2. References in the list

This is an enumeration of all used references. All references from the text should be in the list and vice versa. There are several conventional rules which help to make a proper reference list. Most scientific journals have their own system, which needs to be followed if a manuscript is submitted to that journal. Their rules can be found by going to the website of the publisher,

the specific journal, and the “Guidelines to authors”. Very critical is the *uniformity* of all listed references.

Note that there are different styles, such as the Vancouver style, Harvard style, Chicago style, American Psychological Association (APA) style, Modern Language Association (MLA) style, Turabian style, etc. Their rules with examples can be found on the Internet.

In this manual, the Vancouver referencing style has been followed. However, one of more widely used styles has the main characteristics as follows:

- Enumeration is done strictly alphabetically according to the name of the first author; in the list, all authors must be mentioned.
- More papers of the same author(s) are listed chronologically.
- More papers of the same author(s) within the same year are listed alphabetically.
- Anonymous references are classified according to the first word in the title.
- **For a scientific paper, all information which allows to trace back a reference must be included are: author(s), year, title, journal title, volume number, eventual issue number, and first and last page;**
- The number of an issue of a journal is only added to the volume if paging starts again for each issue of a volume;
- **For a book, the following bibliographic data should be provided: author(s), year, title of the book, editor, city, and eventually the number of pages.**

Each type of document (book, paper, thesis, etc.) has its own way of providing bibliographic information. Examples are listed below. The number(s) behind the type of document refer(s) to the number of the reference in the list at the end of the manual (pg. 65). The numbers 13, 14, 15 refer to the same author(s). This is also the case for the numbers 18, 19, 20, 21, 22 as well as for the numbers 43 and 44.

*Anonymous*                      *report*: 5, 25  
    *book*: 4, 24, 59  
    *catalogue*: 10  
    *manual*: 8

*Book (one or more authors)*: 7, 9, 29, 33, 37, 42, 45, 47, 48, 49, 50, 51, 58, 60, 64, 68, 70, 73

*Frame book*:                      *several parts*: 2, 11, 55, 57, 66  
    *one or more editors*: 6  
    *part of a series*: 12

*Paper out of a frame book*: 13, 14, 15

*Paper out of a journal*: 16, 17, 18, 19, 20, 21, 22, 27, 28, 31, 32, 34, 35, 36, 38, 40, 41, 43, 44, 46, 63, 67, 69, 74, 77

*Original paper is not available*: 2, 60, 62

*Paper cited:* 39

*M.Sc. thesis:* 3

*Ph.D. thesis:* 76

*Lecture:* 25, 53

*Course:* 71, 72

*Proceedings:* 54, 75

*Electronic references:*

*Only the electronic version is available*

*Both the electronic and hard copy can be consulted*

*CD-ROM*

## 6. Writing correctly

### 6.1. Wording and phrases

Scientific data are often not very attractive to most readers except to a very narrow group of specialists whose interest goes to the same research area. But the question is how to make boring facts intriguing for more scientists? There is no universal recipe but a wide space for creative inventions. Here are some suggestions.

### 6.2. Style (after Malmfors et al., 2002)

The used style should be clear, readable, and straightforward. The function of scientific writing is to present information clearly and concisely. It is not intended to entertain people. The stylistic restrictions for popular science writing are very loose, hoping to increase book sales.

One of the most important aspects of scientific writing is the organization of information into a logical progression so that the reader can follow easily. This is also one of the most difficult aspects of writing.

It is not recommended to use colloquial speech, slang, jargon (use technical terms only when necessary) or “childish” words or phrases; for example, “get,” “done,” and “since” or “as” when “because” should be used. Do not use contractions: for example, “don’t” must be “do not” and “isn’t” must be “is not,” etc.

Below you can find some advices regarding which words are recommended to use in a scientific paper and which not.

### 6.3. Alternative words

Do not use electronic dictionaries or translating software. It might lead to strange results. US or UK spellings should be used consistently. To have an English expert reading your manuscript could be a good idea.

Instead of ...	Use ...
Commence	begin
Utilize	use
Finalize	finish
Prioritize	rank
Approximately	about
Ameliorate	improve
Culminate	end

#### 6.4. Tighten your writing (after Malmfors et al., 2002)

If the same idea can be expressed in fewer words, then the writing is wordy. Wordy writing bores the reader and makes it difficult for the reader to understand what you mean. Good writing is tight, and tight writing allows you to convey more information. Tight writing is important, especially when you have to write an abstract with strict limits on the numbers of words or characters allowed.

To tighten your writing, follow these strategies:

- Eliminate redundant words whose meaning is already clear:  
3 months; during the experiment; during 1999; maximum ; experience; plan ; refer ; blue; facts; repeat ; the literature; 10 of 12; existing; alternatives; eliminate.
- Eliminate words that say nothing:  
it is interesting to note that; quite; really; rather, the (especially with plurals); very (if it substitutes for damn!).
- Substitute a single word for a wordy phrase:
- Use infinitives (the *to* form of a verb; e.g., to run) and gerunds (the *-ing* form of a verb; e.g., running) to make a sentence smoother and shorter.

Instead of ...	Use ...	Instead of ...	Use ...
make a decision	decide	make an assumption	assume
make a judgment	judge	due to the fact that	because
make a conclusion	conclude	prior to the start of	before
take into consideration	consider	on a regular basis	regularly
make an adjustment	adjust	a second point is	secondly
in the event that	if	viable option	choice
in close agreement with	agrees with	would seem to suggest	suggests
it seems likely that	likely	despite of the fact that	although
the majority of	most		



- Combine sentences to eliminate unnecessary words and focus attention on key points.
- Put the main idea of your sentence into the subject and verb to reduce the number of words.
- Think about what you *mean* to say, write it in different ways, and choose the tightest one.

Phrases beginning with *of*, *which*, or *that* can often be shortened. Instead of writing “The estimates of the parameters were ...,” it is better to write “Parameter estimates were....” Sentences beginning with *There are* or *It is* can often be tightened. Instead of writing “There are three reasons for these results,” it is better (and stronger) to write, “Three reasons for these results are...”.

### 6.5. Use transitions to link ideas (after Malmfors et al., 2002)

Transition words and phrases (e.g., *and*, *for example* or *during*) indicate connections between ideas. Transitions tell the reader if the next sentence continues the previous idea or starts with a new one. They tell the reader whether the idea that comes next is less important than the previous one. Transitions are used also to introduce the last or most important item, to introduce an example, to compare or contrast ideas, to show cause and effect, to show time, to summarize, or to end. The following are examples of transition words and phrases:

- To show addition or continuation of the same idea:  
and, in addition, also, likewise, first, second, third, similarly
- To introduce the last or most important item:  
finally, moreover, furthermore
- To introduce an example:  
for example (e.g.), to illustrate, for instance, namely, indeed, specifically
- To contrast:  
in contrast, on the other hand, or whereas
- To show that the contrast is more important than the previous idea:  
but, nevertheless, however, on the contrary
- To show cause and effect:  
as a result, for this reason, because, therefore, consequently
- To show time:  
after, next, as, then, before, until, during, when, in future, while, since
- To summarize or end:  
in conclusion, to summarize

### 6.6. Use parallel structure (after Malmfors et al., 2002)

Use the same grammatical form or consistent pattern for ideas that have the same logical function. A parallel structure makes writing smoother, more forceful, and easier to understand, especially when used for a list or a series of ideas. Be sure that each item in the list begins or ends with the proper word form.

A parallel structure is especially useful when writing the “results and discussion” section. Once you decide on the form of the structure to present the result for one variable, use the same pattern to present results for other variables; simply copy, paste, and revise the text. Having mastered the result for one variable, the reader can see the pattern and can understand results easily for other variables.

### 6.7. Social importance

Your paper will be interesting for a much wider audience if you would be able to emphasize the importance of your data for the community even in a distant future.

### 6.8. Epigraphs

Although it depends on publishing requirements, sometimes it is appropriate to put an epigraph before your text itself. An epigraph (from Greek epigrapher—inscription) is a quotation at the beginning of a paper suggesting its theme on beforehand. An epigraph elucidates the main idea of the work or characterizes it *ex parte* of the other, more authoritative person (source).

### 6.9. Remote comparison

While writing a paper on some plant issues, try to find a parallel phenomenon in the animal or fungi world. For example, for better understanding of a role of cereals’ scutellum compare its function with that of an animal stomach.

### 6.10. Emotion is infective

The reader will never become interested in your paper if he will not feel your infusion as the author. Put some emotion into your paper and be enthusiastic about your data.

### 6.11. Grammar, punctuation, numbers, dates

The scientific study of languages is called linguistics. Grammar (Greek—grammatike, from gramma—lit, spelling) is the branch of linguistics that deals with syntax, morphology, phonology, and semantics. In this chapter, grammatical rules will not be discussed, but only some suggestions which will help to make a paper more readable and attractive will be provided.

#### 6.11.1. Hyphens

Hyphens must be used only between those words whose meaning will be lost on being placed separately. For instance, “water-proof cement” is not cement of either water or proof, it is cement defensive to water action. “Acid-fast bacteria” are neither “acid bacteria” nor “fast bacteria” but bacteria resistant to acids.

A hyphen is needed if the first word of a compound is an adverb, such as well, still, or ever (for example, well-known procedure, ever-present danger, or still-new equipment). Three-term

modifiers normally require hyphens: out-of-plane distance, 3-yr-old equipment, 4-mm-thick layer, and signal-to-noise ratio.

Practically any two-word combination that modifies a noun should be hyphenated: air-dried soil, high-temperature chamber, etc.

#### 6.11.2. *Use and misuse of a comma*

Normally a comma is used to emphasize or separate different components of a complex sentence from each other. In fact, a comma in writing plays the same role as a pause in spoken language. It is necessary to remember that all punctuations are used to produce pauses. A period calls for the longest pause. A slightly briefer pause is called for by a dash or set of parentheses. Briefer than those are the pauses called for by colons and semicolons. The comma calls for the briefest pause of all. Thus, a comma is a punctuation mark, indicating a slight pause in the spoken sentence and it is used where there is a listing of items. Besides, a comma is used to separate a nonrestrictive clause or phrase from a main clause.

Although a comma can be tiny and seemingly insignificant, it can largely effect or even reverse the meaning of a sentence. Here are some examples from “The careful Writer: A modern guide for English usage” (Bernstein, 1984):

- a. Was that the latest dope?
- b. Was that the latest, dope?
- a. The Democrats, say the Republicans, are sure to win the next election.
- b. The Democrats say the Republicans are sure to win the next election.
- a. Do not break your bread or roll in your soup.
- b. Do not break your bread, or roll in your soup.

In most cases, it is advisable to keep sentences short and simple with one main idea. If you feel a need to make a compound sentence, which has two main ideas, join it by conjunctions (and, however, but, whereas, while, if, then).

#### 6.11.3. *Long dash*

According to the punctuation guide in *Webster Ninth New Collegiate Dictionary*, a long dash is usually used in the following instances:

- To introduce a summary statement that follows a series of words or phrases: “Oil, steel, and wheat—these are the sinews of industrialization.”
- To attribute a quotation: “My foot is on my native heath ... —Sir Walter Scott.”
- It may be used with a question: “Your question—it was your question, wasn’t it, Mr. Jones? — just can’t be answered.”

- The dash removes the need for a comma if it falls where a comma would normally be used to separate two clauses: “If we don’t succeed—and the critics say we won’t—then the whole project is in jeopardy.”

#### 6.11.4. Short dash

A short dash is longer than a hyphen but shorter than a long dash. The most usual case for using a short dash is the number range. Instead of writing “Atmospheric humidity ranged from 80 to 85%”, you can use “Atmospheric humidity was 80–85%.” Besides, a short dash is used to join nouns of equal importance. An example in population genetics might be the Hardy–Weinberg Law.

In chemistry, a short dash either joins different compounds ( $\text{HCl-H}_2\text{SO}_4$ ) or is used within a compound ( $\text{CH}_3\text{-CH}_2\text{-COOH}$ ).

#### 6.11.5. Parenthesis

Parentheses are used both within one sentence and around one or more sentences, either to separate an informal definition or to set off something that is closely related to the main topic but requires a different treatment.

## 7. Libraries, journals, article selection

### 7.1. Introduction

Libraries provide many important sources of information for researchers. Information sources fall into four general categories:

- Books and similar publications
- Printed periodicals (national and international journals, newspapers, magazines, etc.)
- Miscellaneous printed and non-printed sources (also sound and video recordings)
- Electronic resources (online catalogues of books, periodicals, reference works, bibliographies, full-text databases, etc.)

In addition, theses, catalogues, and dissertations can also be found in libraries. Books are important sources for many research projects. It is often required that students use books, in addition to articles, Internet sites, and other materials during research. Relatively few scientific books are electronically available through the Internet. Most books can be borrowed from the library for a limited period. Libraries collect also printed *periodicals, newspapers, and magazines*, through which numerous articles can be consulted.

Most libraries also provide access to *non-printed sources* such as sound and video recordings and possibly also unpublished documents (e.g., manuscripts or private letters in special collections). The library probably offers reference documents in electronic form as well as

full-text databases. They may also recommend useful Internet sites. The library may even subscribe to journals only available electronically.

Besides the printed and non-printed materials, libraries may provide other services, such as microforms, a media center, interlibrary loans, etc.

Many libraries have a special section devoted to audio recordings (e.g. compact discs, audiotapes, DVDs, long-playing records), video recordings, and multimedia materials. These resources are generally used only in the library, although there may be exceptions, such as for use in the classroom.

Photocopying machines are typically located at various sites in the library, as well as computer terminals that give access to the central catalogue and other databases and to the Internet.

Most library centers provide a variety of software for tasks such as word processing, spreadsheet analysis, database management, desktop publishing, drawing, image processing, and drafting. Output services might include high-quality printing, CD mastering, and image and text scanning.

Most libraries have agreements for *exchange of research materials* on a regional, national, or even international basis. If the library does not have the needed material, it can be asked whether it can be borrowed from another library. Help for interlibrary loan is always available. Finding the source in a nearby library rather than in a faraway one considerably saves time.

As mentioned in the first chapter, scientific communication is essential for development of science. At present, revolutionary changes of the global structure of scientific communication are taking place. Next to the traditional (printed) channels the emergence of electronic channels becomes stronger.

Despite enormous possibilities of the Internet, libraries are still the basic depository of scientific knowledge. They form a reliable and stable communication channel of scientific knowledge. Libraries hold not only printed editions, they also manage electronic editions. They are usually active in different networks. It is their task to systematize, archive, provide adequate reflections, and to organize systems of literature navigation.

The library is generally the most reliable guide when conducting research. To some extent, librarians evaluate resources for authority and quality before acquiring them for use in research. Therefore, it is advisable to become thoroughly acquainted with libraries available to scientists and to take full advantage of the resources and services they provide on-site and over the Internet.

At the same time, assessing Internet resources is a challenge. Scientists regularly consult and use facts and ideas from Internet sources to complement those derived from traditional printed sources. However, it should be taken in mind that printed literature is generally issued by reputable publishers, like international journal publishers, university presses and others, accepting accountability for the quality and reliability of the documents they distribute. The number of electronic publications grows very quickly. The reliability of them is something that needs full attention.

## 7.2. Libraries and literature search

Most academic libraries provide an online central information system to guide students and faculty members to research sources. The system ordinarily includes:

- The catalogue of holdings (books, periodicals, electronic sources, audiovisual materials, etc.).
- Bibliographic databases.
- Other electronic sources, including reference works, full-text databases to which the library subscribes, and recommended Internet sites to which the library provides links.

An important part of a library's central information system is the online catalogue of holdings. However, there is no standard system for online catalogues. At the start of a research project, relevant *reference documents should be consulted*. Some of them, such as indexes and bibliographies, categorize research materials by subject and provide data that permit to locate sources, author, title, date of publication, subject section, etc.

Present-day scientific libraries subscribe to and make generally available a wide variety of databases: not only those containing bibliographic citations and abstracts, which guide researchers to relevant sources, but also *full-text databases*, which offer complete texts. Libraries likely subscribe to full-text databases of reference documents as well as to articles. If necessary data are lacking in scientific libraries, the website of the library may be consulted. Virtually all full-text databases are searchable by author, title, keywords, etc. (see Section 7.3.)

The information system of scientific libraries might also be part of a network linking catalogues in several libraries. For instance, the system in one university might permit to search for documents of local public libraries or of other institutions.

## 7.3. Internet sources

At the beginning of twenty-first century, the structure of scientific communication entered a new phase. The internet always and everywhere enables scientists to have access to research data. The nonperfect traditional system of information diffusion is becoming inefficient. In addition, scientific journals are expensive and their circulation is limited.

Especially the idea of "open access" is linked to the advent of the public internet. "Open access" is the perfect accessibility for any user to read, to load, to copy, and to print full texts without financial, legal, or conventional restrictions. *But only the author may check the integrity of the text.*

So, scientists regularly use facts and ideas from Internet sources to complement those derived from traditional printed sources. Through the World Wide Web (www), a scientist can read and transfer material from library catalogues and millions of other useful sites, created by professional organizations, governmental agencies, commercial enterprises (e.g., publishers, encyclopedia, news organizations, etc.), and educational institutions (e.g., universities, research centers, academic departments, etc.)). These sites provide different information, full and short texts of various documents (articles, books, historical papers, maps, etc.) and audiovisual materials (photo, sound and video recordings, animations, etc.).

To search for a specific information one can use *recommended sites*. In addition to online databases available through subscription, scientific libraries may recommend other important Internet sources that are selected after careful evaluation and consultation. Check the website of the library for links to such resources. A librarian might also be able to advise sites relevant to a specific research.

The Internet provides a lot of information. Practically all research topics and research papers can be found in different databases. The use of keywords and combinations of them are necessary to get the required information. Some search tools, such as Pubmed ([www.pubmed.com](http://www.pubmed.com)), Google scholar ([www.scholar.google.com](http://www.scholar.google.com)), Scifinder Scholar (<https://scifinder.cas.org>), Scopus ([www.scopus.com](http://www.scopus.com)), Web of Science (<http://thomsonreuters.com/web-of-science>), digital object identifier (DOI) (<http://dx.doi.org>), etc., offer hierarchically arranged subject directories through which you can navigate until you find specific topics you wish to explore.

There are special Internet search systems for scientific information from only educational and scientific editions. It is known that the search is realized through electronic sources and books, periodicals, bibliographic databases, etc., on the Internet. Characteristic examples of scientific searching systems on the Internet are "Scirus" and "Google Scholar."

"Scirus" is a universal scientific searching system. Full-text search is done on clauses of magazines of most large foreign publishers (about 17 million articles), articles in large archives of articles and preprints, and scientific resources of the Internet (over 2.1 milliard indexed pages). It has repeatedly been recognized as the best specific searching system.

"Google Scholar" is a searching system on scientific literature. It includes articles of large scientific publishers, archives of preprints and publications on sites of universities, science foundations, and other scientific organizations. It is important to know that "Google Scholar" calculates the citations of publications and allows finding articles, containing references on those papers, which were already found.

## 7.4. Scientific journals

### 7.4.1. Types of scientific journals

Primary journals	Secondary journals	Monographs	Magazines
(New knowledge)	(Databases)	Handbooks	

Development of science is based on earlier developed knowledge increased with new findings. However, to guarantee the quality of the scientific developments, scientific findings must be made public upon peer review. The distribution of knowledge can occur via hard copies of journals and other scientific documents or electronically published documents. There are also more and more open access journals. Journals are public documents to which scientists from all over the world can have access. Most journals are limited in scope. Usually, they bring contributions

from one branch of science. Some journals are proud on spanning the often-vague boundaries separating different scientific areas.

Unpublished results are useless in a very real sense, and they certainly are not worth the investment required to obtain them (except in the special case of work whose purpose requires that it be secret or available only to a limited audience). Publication makes one's results available for others to build upon, and it allows one to become more extensively known. The latter function may provide the less altruistic motive, but it is usually foremost in the mind of young scientist-authors, partly because employers are particularly sensitive to the number of papers and they review the publications of a candidate when hiring or promoting them. Publishing in a scientific journal is comparable to self-advertising; it attracts attention to the quality (and quantity) of a scientist's work.

Individual journal issues can appear at different time intervals (e.g., 4, 6, or 12 issues a year). All issues of 1 year form a volume of that journal. Publishers of journals are mainly commercial companies. There are also societies publishing journals (e.g., Soil Science Society of America publishes the "Journal of Environmental Quality"). It is very important that the publishing schedule is as constant as possible. Only on this condition a journal can be taken up by the "Institute for Scientific Information (ISI)" of Philadelphia (USA), now in hands of the Thomson Corporation. ISI is the organization publishing the citation index and other data about the impact of journals as well as individual articles.

Of all types of scientific journals, the most evident and indispensable ones are those called *primary journals* (the "primary literature"). The content of these journals brings material which is for the first time published. A primary journal describes new experiments or theoretical approaches, reports the results, and discusses their implications, and the author's conclusions. Information is conveyed as exactly and shortly as possible, but presumably in a way that permits others to understand the techniques used and the results obtained. Any scientist with compliant training can repeat a published experiment or derivation based solely on the contents of the article disclosing it. Needless to say, that there are thousands of primary journals. Even journals covering more or less the same discipline are sometimes numerous. Therefore, it is not easy for a scientist to consult and know all published information in his field of interest.

Earlier, it was implied that there are various kinds of primary journals publishing various category of articles. For results that are limited in scope or important enough for rapid dissemination, or, on the other hand, for results that still need to be regarded as somewhat tentative, the best form of publication is what is known as a *short communication* or a *note* (sometimes called a "*preliminary note*"). Articles of this kind are limited to a few categories and are rarely subdivided into formal "Experimental," "Results," and "Discussion" sections, as is done with "full papers." Also, the "Introduction" (if any) is often very condensed. In many cases, experimental details are omitted, the implicit assumption being that a more complete explanation of the work will appear later (an obligation some researchers often fail to fulfill). Comprehensive or lengthy descriptions of significant results or discoveries deserve to be written more formally. Such manuscripts should be submitted to a standard primary journal for publication as a traditional "paper" (sometimes called a full paper).



An important characteristic of a paper is that all information must be verifiable and be of a high degree of novelty. Space in journals (and libraries) is precious. It is generally agreed that priority is given to those results which are significant for progress in a specific discipline. The more “prestigious” a journal, the stricter will be its definition of “significant.”

Although primary journals may be most important, there are other kinds of journals with significant roles. Indeed, a scientist today would be lost if the only source of published information is primary literature. Because of the huge amount of published material, it has become literally impossible to keep abreast of the progress in even a comparatively narrow field by attempting to read all relevant primary journals. For this reason, *secondary journals* have been developed. These journals bring only abstracts of published material in primary journals. Secondary journals can appear as hard copy, but now, almost always as electronic databases. Abstract journals or other secondary magazines should be consulted by keywords. This is the reason primary articles always provide keywords. They facilitate literature retrieval.

Most literature specialists begin their search by identifying review journals (tertiary literature). It would seem logical that *monographs*, *handbooks*, etc., also belong to this group. On the other hand, some authorities treat these, including reviews, as part of the secondary literature, placing abstracts in the same category as bibliographies and catalogues.

A scientist starting with a new subject will always try to find a review journal or a review paper. A review is an article providing a concise, structured overview of some relatively narrow topic. Scientists read reviews to acquire background information in areas with which they are not familiar, or as sources to find the original literature. Unlike articles in primary journals, reviews are generally written at the request of an editor to a specialist whose own original relevant papers testify his or her interest, knowledge, and competence in the field to be treated. Ambitious authors should aspire to write a review article at least once in their lives, and it is something of an honor to be asked to do so. Not all review journals are similar. Some have a tradition of publishing what might be termed complete reviews, while others deliberately solicit reviews that are critical and selective. Reviews in journals intended for a purely academic or professional readership are very brief and often documented by hundreds of literature references. A journal that is more educational or of general academic nature, on the other hand, will solicit articles appealing to the audience with a scientific background but little previous knowledge of the subject and thus no interest in details. The journals “Science” and “Nature” contain reviews of this kind.

A scientific *magazine* is intended for an even wider public, primarily laymen. Its success depends on authors who are willing to put most of their effort into carefully explaining very basic suggestions and their interrelations, while at the same time devoting special attention to historical background and prospects connected to the subject.

In recent years, the language of publication has also become a matter of demanding serious consideration. No longer can the choice of language be made solely based on an author’s own nationality or linguistic ability. It seems safe to say that if one’s object is to reach the largest possible audience, or if one is anxious to establish an international reputation, then it is advisable to publish in English.

In recent years, more and more “Open Access Journals” (OAJ) appear on the market.

The advantage of such a journal is the rapid appearance on the scientific market and the possibility to add several annexes to the paper as well as documents in color. A lot of information can be found in: <http://www.elsevier.com/about/open-access>. A good example of an open access paper can be found by the following address:

<http://link.springer.com/article/10.1007/s11032-013-9862-8> (Mol Breeding (2013) 32:189–210).

One should, however, be very careful in considering an OAJ. Check the reputation of the editor and look at the composition of the editorial board. Because the author(s) pays for the publication, some organizations smell a source of money. They usually promise a quick handling of the manuscript with a thorough review. Relevant information about this problem can be found in: <http://www.sciencemag.org/content/342/6154/60.full>.

(Bohannon J. (2013). Who’s Afraid of Peer Review? Science 342(6154), 60–65. DOI: 10.1126/science.342.6154.60).

#### 7.4.2. Quality of scientific journals

### Impact factor—discipline dependent !!!

To check the quality of information, a full and correct source information (bibliography) is necessary. This is often lacking with electronic sources. Information on the Internet is often provided without references. Writing “I found this on the World Wide Web” might be sufficient for a newspaper, but not for a scientific document.

Results of research must be published and shown to colleagues. In their publications, scientists show how they have built up their knowledge and how they used existing knowledge. This becomes clear from the reference list of a document. In fact, science can be studied by the scientific literature. This provides a picture of the scientific activity. Scientific journals form the communication channel among scientists in the same field.

The *number of papers* of a certain research group gives an idea of the scientific *production* of that group. The number of times the work of a certain group is cited in other publications is a measure of the *impact* of the (international) visibility (and importance) of the document. If a document is often cited, it is an indication that it is important. Journals which publish articles that are very often cited will be important journals, or *journals with a high impact*. Those journals are often called “central” journals. They work with a peer review system to check the quality of the submitted manuscripts. Journals not using or only limitedly using peer reviews are less important. The Institute for Scientific Information (ISI) looks to all citations of articles published in international peer-reviewed journals. This information can be found in databases, the Citation Indexes, covering the most important journals. The mostly used indexes are the Arts & Humanities Citation Index, the Social Science Citation Index, and the Science

Citation Index Expanded (SCI). In the “Journal Citation Reports” the following information can be found:

- The most cited journals in a specific field.
- The journals with the highest impact factor.
- The most frequently seen journals.
- The papers with the highest citation score.

The bibliometric analysis tries to visualize the above-mentioned parameters “**publications (P)**” (productions and productivity), “**citations (C)**” to these publications (with or without self-citations) and “**impact of these publications (C/P)**” (citations per publication). Self-citations are citations to papers of the author(s) itself. In fact, this is some manipulation of the impact of a paper. Next to the impact of an article, one can also calculate the impact of a journal (**Impact factor, IF**) (an arithmetic mean of citations in a particular (citing) year to a particular set of articles in a particular journal 1 or 2 years earlier). The impact factor of a journal also depends on the period during which the citations are counted (citation windows). A **citation window** is often a few years from the year of publication, e.g., of an article published in 2000, the citations can be counted in the period 2001–2002. One can also use different windows to see the evolution of, e.g., C, P, or C/P, also in relation with international trends. The ratio of a local impact to the world impact is a measure for the quality of local scientific research of a research group, an individual, or an institute. Not only citations of articles can be calculated, but also of all articles in a particular journal. This is the “**Journal Citation Score**” (JCS). When a scientist publishes in different journals, a weighted mean journal citation score can be calculated (**JCSm**). The impact factor of a journal is important, because it allows **ranking of journals** within the same discipline. Scientists should try to publish in an as highly ranked journal as possible.

As an example, in **Table 9**, a list of few journals with different IF is given (data for 2012). This information can be found in Journal Citation Reports of ISI, Web of Knowledge. This database includes also the abbreviation of journals, ISSN, total cites, impact history, and citation history and number of issues.

It is important to note that there are differences among disciplines regarding citation. Authors publishing in the field of “molecular biology” or “biochemistry” cite a lot more than in the field of “arithmetic” or “physics.” To compare these different citation habits, one uses the relation with the world average citation of a specific field of sciences (**FCS**). Here also, different fields of sciences can be covered, and a weighted world average citation can be used. It has no sense at all to compare impact factors of different disciplines, as the citation habit can be totally different. It can only be done after normalization.

#### 7.4.3. Article retrieval

If some new subject needs to be explored, you can start searching for articles via several keywords in the Web of Knowledge or other databases. Once a recent article has been found, you can further explore more articles (or books) by the reference list of the first article and

**Table 9.** List of some journals (abbreviated and in full) with their impact factor, total cites, and number of issues in 2012.

Abbreviated journal title Full Title	Impact factor (IF)	Total cites	Number of issues
Nature	38.159	554.745	51
Science	31.027	508.489	51
Adv. Appl. Mech. Advances in Applied Mechanics	11.333	960	1
Aliment. Pharm. Ther. Alimentary Pharmacology & Therapeutics	4.548	13.426	24
Adv. Inorg. Chem. Advances in Inorganic Chemistry	2.714	1.666	1
Acta Bioeng. Biomech. Acta Bioengineering and Biomechanics	0.333	109	2
Adsorption	1.553	1.455	6

**Table example 9.**

<b>Boolean operators:</b>	<b>AND, OR, NOT, NEAR, WITH, *, ?</b>
<b>Web of Science – Web of Knowledge</b>	

continue this process till a good basic knowledge about the subject has been found. In the meantime, some journal titles and eventually book titles which can be further consulted will have been noted. This system is also called the “snowball system”. The only negative point is that the found information goes back in time and very recent results will be missing. In addition, there is some time between the gathering of results and the final publication of an article. It is also important to look at the reference lists in articles with criticism. Some reference lists can contain a lot of self-citations, or are very short or too long and miss essential references.

In the Web of Knowledge, Scholar Google, etc. one can efficiently **search using author names, or journal names or keywords**. The search can be done in a focused way using boolean operators (George Boole, 1815–1864). The three most important ones are: **AND**, **OR**, and **NOT**. They can broaden or narrow the search by combining words or phrases. Their use is as follows:

- AND is used to combine two or more keywords; it narrows a search.
- OR is used to group keywords (use eventually brackets); it broadens.
- NOT is used to exclude keywords; *caution!* it is easy to exclude relevant information.

Other operators are **NEAR** and **WITH**.

- NEAR between two keywords means that both should be within the same sentence.

- WITH between two keywords means that both can be found in the same field (e.g., abstract, introduction, etc.).

Additional tools are as follows:

- **Truncation symbol (\*):** This symbol replaces the rest of the word. As such one can include also, e.g., plurals of words.

Example: NITR\* covers, e.g., NITROGEN, NITRATE, NITRITE, NITROGENEOUS.

- **Wildcard (?):** This symbol is mainly used to overcome spelling differences (American English versus UK English).

Example: COLO?R ↔ COLOR ↔ COLOUR; MINERALI?E ↔ MINERALISE ↔ MINERALIZE

### Example of the use of some boolean operators

*Question: try to find papers covering the fields “carbon dioxide” and “methane” and “nitrous oxide” and their combinations.*

Used key-words	Records found (02/2014)
Carbon dioxide	137.564
Methane	98.680
Nitrous oxide	23.334
Carbon dioxide AND methane AND nitrous oxide	1.245
Carbon dioxide AND methane AND nitrous oxide NOT agriculture	1.089

Another way to retrieve an article is the use of DOI (digital object identifier). Papers can be identified by a code. If the DOI code is known, you can retrieve the paper. The internet address is <http://dx.doi.org>.

## 7.5. Collection and evaluation of references

References:	<ul style="list-style-type: none"> <li>• keep a full record of all relevant ones</li> <li>• check reliability !!!</li> </ul>
-------------	--

### 7.5.1. Working bibliography

Upon tracing and finding information on a specific topic, you should keep track of the consulted sources. A record of these sources is called a *working bibliography*. Each record should contain the name of the author(s), title of the document, name of the series wherein the document is published, all bibliographic information (year, volume, number, pages), and the place where the document can be found. Your preliminary reading will probably provide the first

titles for this list. Other titles will emerge when you consult more references and the library's central catalogue and when you explore the Internet. If you go carefully through the reference list and notes of each document you consult, you will often find additional important sources. As such, your working bibliography will change during your research. It will, however, be useful for editing your final list of references.

No doubt, the use of different relevant computer files with information on your studied topic will help you to keep a good record of all necessary information for later writing up your chapters.

The rules to set up a correct list of references are given in Section 5.

Items of the working bibliography can look as follows:

For a paper:	<hr/> Authors: Michaelson, H.B. (1982) Title: Strategy for the Engineer Author Bibliographic data: Chem. Eng. Int. Ed.93 (15), 50–60, 1986 Where can it be found? Library Faculty Bioscience Engineering, Ghent University
For a book:	Authors: Luellen, W.R. (2001) Title: Fine-Tuning Your Writing Editors and address: Wise Owl Publishing Company, Madison, USA Pages: 346 p Where did you find the book? Library, Biological Sciences, Ghent University <hr/>

### 7.5.2. Reliability of literature sources

It is very important that you carefully read all published material before using it in your own work. You must be critical toward all information, which is not always easy. Not all published material is equally thorough and can be trusted. Printed material has a higher reliability than information on the Internet. Published research material has practically always gone through a review process. Editors constantly look for experts to review (peer review) submitted research material. The reviewers carefully check the full manuscript and report all mistakes, doubts, unclear facts, degree of novelty, originality, etc. to the editor, who communicates with the corresponding author. Unfortunately, a lot of manuscripts do not get through the review process and return to the author. Several manuscripts will be accepted upon minor or even major revision. Eventually, it is possible that a manuscript does not fit within the scope of the journal. It is of utmost importance to consult all information about a possible journal, even before you start writing. When you select, a certain journal go through its guidelines first. Manuscripts submitted to a refereed journal must undergo rigorous scrutiny before they can be published.

Assessing Internet sources is a lot more difficult. Some Internet publications are peer-reviewed, but for sure not all of them. Therefore, Internet information has often a low degree of reliability. At any time, the provided information can be changed or even removed from the Internet. There is often no proof of a previous peer review. If, however, information from the Internet is used in scientific documents, the authors should always mention the date of consultation of the source. This is because the information can change at any time.

The publication date of a printed source indicates how actual the document is. Although online documents can be continuously updated, many remain in their original state and, depending on the subject, may be out-of-date.

Actually, a lot of "Open Access Journals" appear on the scientific market. It is very important to check the reliability of these journals. A look at the editor and the editorial board can provide information on the reliability. Recognizing well-known scientists in the editorial board provides some guaranty about reliability. An interesting cite about this problem is <http://www.sciencemag.org/content/342/6154/60.full>. See also Section 7.4.1.

## 8. Authorship and ethics

**Authors and co-authors** of scientific publications have a variety of responsibilities. All authors, including co-authors, are expected to have made reasonable attempts to check findings submitted to academic journals for publication. Simultaneous submission of scientific findings to more than one journal or duplicate publication of findings is usually regarded as misconduct.

The central obligation of authors is to present a concise, accurate account of the research performed as well as an objective discussion of its significance. The results of research should be recorded and maintained in a form that allows analysis and review, both by collaborators before publication and by other scientists for a reasonable period after publication. Exceptions may be appropriate in certain circumstances to preserve privacy, to assure patent protection, or for similar reasons. Authors are expected to keep all study data for later examination even after publication. The failure to keep data may be regarded as misconduct. A paper should contain sufficient detail and references to public sources of information to permit others to repeat the work.

Research today, more than ever before, tends to be a team effort. Anyone who has made a significant contribution to a set of results should be included as co-author. For example, a publication based on a thesis project should normally have also the thesis advisor as co-author. After all, this is the person who probably thought of the project in the first place and who guided much of its subsequent development. When some people have contributed to a research result, it is necessary to establish the order in which their names will be cited. In the past, the author with the highest seniority usually insisted on being listed first, regardless of who did most of the work, but this practice is changing. Today, the order generally reflects a mutual assessment of the relative importance of the authors' respective roles, although alphabetical arrangement is also applicable in some journals. The first-named author enjoys a unique advantage in

that the article is likely always to be associated with his or her name. Accepting on an order can give trouble at times, and both generosity and vanity are occasionally involved. The only piece of advice that can be offered is that the problem be worked out in advance.

In case the paper is the result of a team, it is more difficult to define the order of authors. Research groups have different conventions, either the alphabetical order or an order of contribution (greatest contribution first), and reverse order of seniority (head of the laboratory last). If the team is formed from more than one institution, authors may be grouped by address. Addresses of authors should be given according to the journal style. Be sure the full international address is given so that interested people can contact the authors. The first address should be the institution where most of the work was conducted. If the first author has been relocated after completing the work, the address of the institution should remain the original one and a footnote should indicate his or her current address. With more than one institution, superscripts are often used to indicate who works where. One author may be identified for correspondence and reprint requests. When only two people have contributed to the research, this issue can be solved in a simple way, the person who did the research and wrote the paper comes first followed by the second one. It is advisable, upon submission, to add a statement signed by all authors that they share the responsibility and accountability for the research.

Agencies that funded the research must be correctly acknowledged. Persons who intellectually contributed significantly, but not enough to justify an authorship, should be listed in another paragraph of the acknowledgment. Provide their function or contribution. Persons who technically contributed should be mentioned in a separate paragraph. A written permission from the persons in the acknowledgment should be obtained by the authors.

All persons listed as authors must have substantially contributed to and accept the responsibility for the presented research. Anyway, it should be more than a general supervision. An author must be able to fully defend the presented research. A minimum requirement for authorship is the participation in the concept and design of the research program, participation in the acquisition, analysis, and interpretation of data as well as drafting, critically revising, and final approval of the article. All these conditions must be met.

**The ethical issues of the editor.** The editor of a journal has the complete responsibility and authority to accept or reject a manuscript submitted for publication. The editor may consult associate editors or reviewers for an evaluation and final decision. An editor should give prompt and unbiased consideration to all manuscripts offered for publication, judging each on its merits without any restriction and respecting the intellectual independence of the authors. The editor or editorial staff should not discuss the submitted manuscript to anyone else than to the reviewers and the author(s). Editors as well as reviewers should not use any material from the submitted manuscript in their own work.

The author-editor relationship should be ethical not only in case of accepting the article but also when it has been rejected. Usually editors send to the authors parts or all information from peer-reviewers. This helps the author to better understand the mistakes he made, and to make a better article next time or to improve his manuscript. Rejection of a manuscript may even play a significant positive role in the future research career of a scientist.



## 9. Plagiarism, falsification, and fabrication

Plagiarism	Stealing of ideas, data, expressions, text ...
Falsification	Changing, manipulating data, protocols
Fabrication	Making up data and results and publish them
They all taint the reputation of the scientist	

Each scientist is responsible for protecting the integrity of science. In scientific communication, there are two kinds of ethical errors:

- Plagiarizing the work of others.
- Distorting your own data by falsification and fabrication.

In fact, it is both a legal and an ethical issue. Plagiarism, falsification of data, and fabrications taint the reputation of individuals and institutions.

**Plagiarism** (derived from the Latin word *plagiarius* ("kidnapper")) refers to a form of cheating. The dictionary defines the term as some kind of literary theft or stealing. It is plagiarism when ideas, information, or expressions are used from somebody else without acknowledging the source. This is intellectual theft.

The charge of plagiarism is a serious one for all writers, including researchers. Everybody exposed as plagiarist suffers from severe penalties and lives with the distrust.

You plagiarize if

- you retype and submit work from somebody else as your own work;
- your text contains important portions from a single source without alterations and identifying the source;
- you change keywords and phrases but retain the essential content of the source;
- you paraphrase information from different sources, made to fit together;
- you copy text from the Internet and paste it into your paper without quotation marks or without citing the source; and
- you do not use quotation marks to cite.

Because research can have an effect on the public opinion, authors must present their work with great care. They must indicate the source whenever they refer to ideas, facts, or words of somebody else, whether they agree with, or object to the source. As such, the work of others is recognized.

To guard against plagiarism, be familiar with the literature in your discipline. You should refer to the opinions or results from other researchers and give due credit, but too much reliance on other's ideas or just reporting other writer's idea into your own words is plagiarism.

A research paper always synthesizes relevant previous work and mixes it with own ideas on the subject. Therefore, you can use words, facts, and thoughts in your research paper from other researchers, but the used material cannot be presented as if it was your own work.

The availability of research material on the Internet and the ease of transmitting, modifying, and using it has led to plagiarism in many cases. In this area, the need to acknowledge the authorship of individual documents is a question. Professional writers recognize the importance of avoiding plagiarism whether they base their research on printed or electronic publications. They cite their sources and mark the passages they quote.

Reusing a research paper, collaborative work, and copyright infringement are the other issues related to plagiarism.

You can avoid plagiarism by keeping a list of all authors and their papers you have gone through during your research, and by consulting this list when you prepare your own paper. It is important to make a difference between your own ideas and the summaries you made of the papers of other researchers. Clearly and correctly identify all sources you used.

Self-plagiarism or multiple publication of the same material with different titles and/or in different journals is sometimes also considered as misconduct.

Perhaps the easiest form of research misconduct is **fabrication or falsification** of data. As science is a very strong career-driven discipline, it is not surprising. To obtain ongoing support and funding, it is important to produce papers of high standard in highly ranked journals. The expression “publish or perish” is well known and this wrongly motivates scientists to fabricate or falsify results. Fabrication and falsification are two points along a spectrum, but both are serious forms of misconduct. They result in a scientific record that does not accurately reflect the observed truth.

In many scientific fields, results are often difficult to be reproduced accurately, being obscured by artifacts. That means that even if a scientist does falsify data, he can expect to get away with it—or at least claim innocence if his results conflict with others in the same field.

**Falsification** refers to the alteration of research materials, equipment, and protocols. Falsification is manipulating research processes, or changing or omitting data or results such that the research is not accurately represented in the research record. Falsification includes reporting false information about experiments and false citations of the sources of information.

Falsification is the invention of information or citations. It is a blatant act of academic dishonesty. Falsification can be an act of inclusion. If, for example, you write that certain fertilizing systems allow increasing the vitamin A content in fruit, but you do not observe this in any citable source, you have falsified information. If you claim that the same fact is included in a paper from certain authors, but no such reference exists, you have also falsified the information. Falsification can also be an act of omission. If, for example, you report that all published reports indicate that 40% of heavy metals in soil are bound to organic matter, but you omit those two references in your possession report that found only 25% bound to the organic matter, you have falsified the information.

Forms of scientific misconduct include **fabrication**. This is making up data or results and publishing them. Fabrication refers to the invention, recording, or reporting of false data. Also, it is fabricating research procedures to make it appear that the results of one process are the results of several processes.

Examples of fabrication are citations of information not taken from the source indicated, listings of sources in a bibliography or other reports not used in that project, as well as inventing data or source information in experiments.

Distorting data intentionally is inexcusable. However, that which is not intentional can also be detrimental to science and to your reputation. Unintentional dishonesty can also affect communication. We know when we speak or write an outright lie, but we must also be sure our statements are not misleading.

## 10. Poster presentation

ABC of a good poster presentation:

Audience, Brief, Clear, Devoted, Enthusiastic

### 10.1. General

Progress of scientific knowledge also depends on how efficiently scientists can communicate their results to colleagues. For a long time, posters have been and remain until now an important part of data transferring and interchange. If you ever formerly took part in a conference, an important part of scientific information was presented by posters, in the poster session place. Using poster papers reduces the number of oral presentations and permits scientists to have a discussion. This makes a poster session one of the most important parts of communication at research conferences. Including posters to the schedule of a meeting will allow increasing scientific exchange. So, posters show results of scientific achievements, but the process of making them is sometimes a rather difficult task for scientists. Each of the poster elements should be adapted to the audience, which may include people with a different level of familiarity with your topic and methods.

There are some particularities which distinguish posters from other ways of scientific communication:

- personal contact;
- meeting with a specific scientific audience with a high level of interests;
- time for direct discussion;
- both speaker and audience are standing;
- no moderator, no buffer;

- audience is free;
- time limit flexible; and
- handouts and business cards are helpful, easy to exchange addresses.

By the end of an active poster session, you may have learned as much from your viewers as they have from you, especially if the topic, methods, or audience are new to you. Scientific audiences have very often a different background. Some of them work in the same area and are familiar with your work, while others work in a similar or different area. Because a poster reflects both you and your organization, it should always look professional, regardless of the audience.

To organize a good poster one should pay attention to the following:

- the type of audience;
- what will be the information to be given to the audience;
- an accessible poster format with a good and attractive title, full list of authors, affiliation, introduction, problem, method, results, and conclusions;
- setting down in writing the rough draft of the story;
- selecting good pictures, figures, graphics, tables and other design elements explaining your text; and
- preparing of complementary information (copies of your research papers, journal articles, fact sheets, brochures, flyers, business cards, program souvenirs, disks) for the audience.

10.2. Poster structure

Structure, layout, and design of posters are often determined by the requirements of the conference or workshop. However, there are common peculiarities which are inherent for each of them (Figure 23):

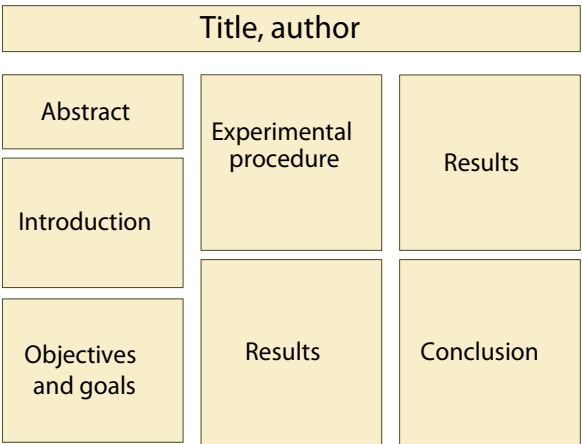


Figure 23. An example of poster structure.

- title, author(s), affiliation;
- abstract;
- introduction;
- objectives and goals;
- experimental procedure;
- results; and
- conclusions.

#### *10.2.1. Title*

The title, author(s), institutional affiliation(s), and eventually the poster number are put on top of the poster. Letter size should be at least 2.54 cm high or must be readable from 1.5 to 2.0 m away. If space permits, use names as well as first names for authors and their affiliation. You can align to the left or center the text once it has been formatted, based upon personal preferences and space constraints. Sometimes, authors put their picture in the corner of that top part. To increase the attractiveness of a poster, it is good to think on a title which is a bit provocative.

#### *10.2.2. Abstract*

The abstract should be able to tell quickly the value of the presentation and provide the literature searcher enough information to assess its value. With the abstract, you should strive for an impersonal and informative account. Give a clear, grammatically accurate, exact, and stylistically uniform treatment of the subject. The statement should give a brief account of the purpose, need, and significance of the investigation. Give a brief account of the methods, emphasizing specific items. Identify scientific names of plants, organisms, and chemicals.

#### *10.2.3. Introduction*

This section should be short and be composed mostly of the general and specific research objectives, a few lines about the context of the work, and a clear statement of the hypotheses.

#### *10.2.4. Objectives and goals*

In short, objectives are the steps needed to get goals. Goals are broad, generalized statements about what is to be learned. Goals are statements, specifying the accomplishments to be achieved. The objectives are statements of the specific activities required to achieve the goals.

#### *10.2.5. Materials and methods*

This part shows the main aspects of the used material and the followed methodology. The description should be complete enough to enable someone else to repeat your work. If different experiments are carried out, it might even be possible to present the methodology and the

results of the first experiment, immediately followed by the methodology and results of the next experiment. This can be another order in which the experiments were performed.

#### *10.2.6. Results*

Results occupy the largest portion of the poster. Once the data are collected, you must analyze results, without interpretation, in an orderly and logical sequence using both the illustrative materials, text and data. This section will probably involve little text and more graphics or tables. You should make the significance and originality of the work very clear because viewers from other specialties may not be aware of its importance. Guide with arrows or numbering the viewers through the results sections.

#### *10.2.7. Conclusions*

Conclusions are often the most difficult part to write. A scientist needs to keep in mind that the conclusion is often what a reader remembers best. A conclusion provides a thoughtful end to a piece of writing. Your conclusion should be the best part of your poster. Scientists draw conclusions by examining the data from the experiment. There are basically two possible outcomes. Either the experiment supports the hypothesis and can be regarded as true, or the experiment disproves the hypothesis as false.

Because the top part of a poster is the most attractive place to look at, one sees more and more; also a short conclusion statement at the top of the poster, below the title, authors, and affiliation looks more noticeable.

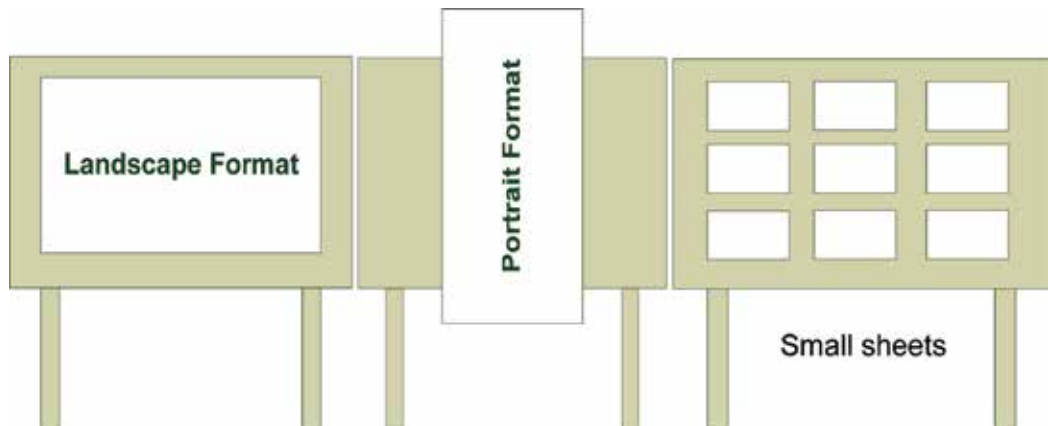
### **10.3. Poster design**

The subject of design is complex, and rules can be broken creatively and pleasingly if you have an artistic flair. A few guidelines, however, will help you make a poster more accessible, attractive, and interesting. Many scientists consider that a good poster must have 30–40% text, 30–40% graphics, and 30–40% empty.

#### *10.3.1. Layout*

A poster can have the “portrait” form or the “landscape” form. You should check with the conference or symposium organizer about the size and format of the poster boards. The portrait form is mostly used. The poster size is determined by the dimension of poster boards of the conference. The standard size of a poster (width 70 × height 100 cm) would be the best solution. At first glance, the viewer should see a readable, legible, well organized, and succinct poster with a neat arrangement of pictures and/or illustrations and text. Small posters or posters made from small sheets require an ordinary color printer, but they do not have good appearance and are not easily readable (**Figure 24**).

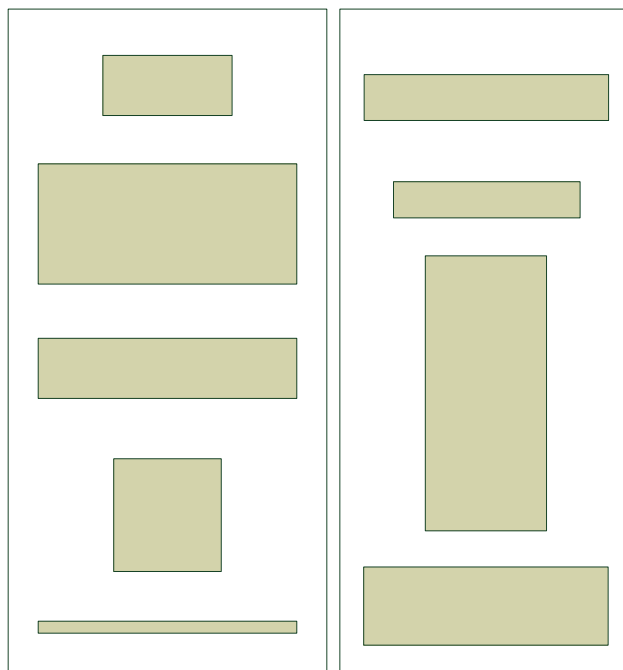
Posters should have a good visual balance of figures and text, separated by some open space. There are three types of balance: formal or symmetrical (**Figure 25**), informal or asymmetrical (**Figure 26**), and radial (**Figure 27**).



**Figure 24.** Three different poster layouts.

To follow the sequence of the different topics of the poster, numbers or arrows can be used. They lead the viewer through the display (**Figure 28**).

To create visual interest to your poster, use elements of different sizes and proportions, leave open space, bring the most important aspect of the poster to the center and single it out with a figure or color (**Figure 29**).



**Figure 25.** Symmetrical balance.

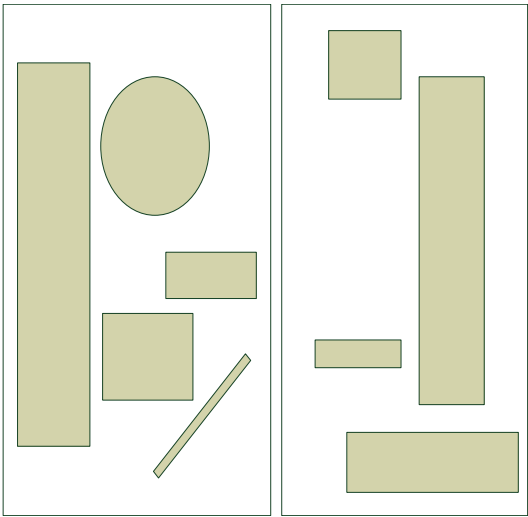


Figure 26. Asymmetrical balance.

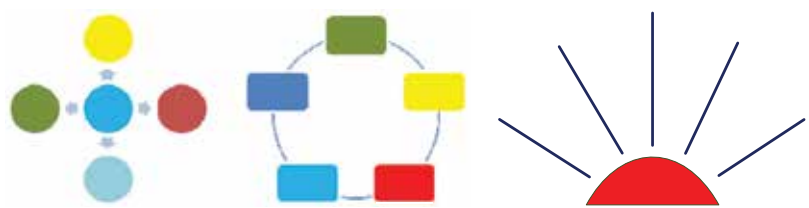


Figure 27. Radial balance.

Keep in mind that European people traditionally begin to read in the left upper corner, then run to the vertical right corner, later go through bias to the left bottom corner and at last move across to the right bottom corner (**Figure 30**). This trend is like the Z letter. You may put the hard elements in the top right corner to fix the glare.

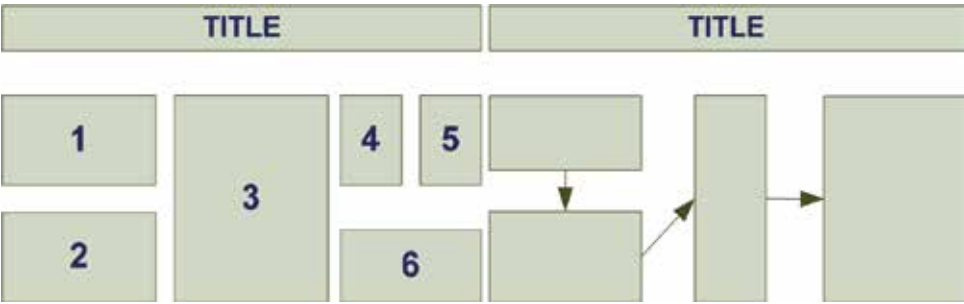
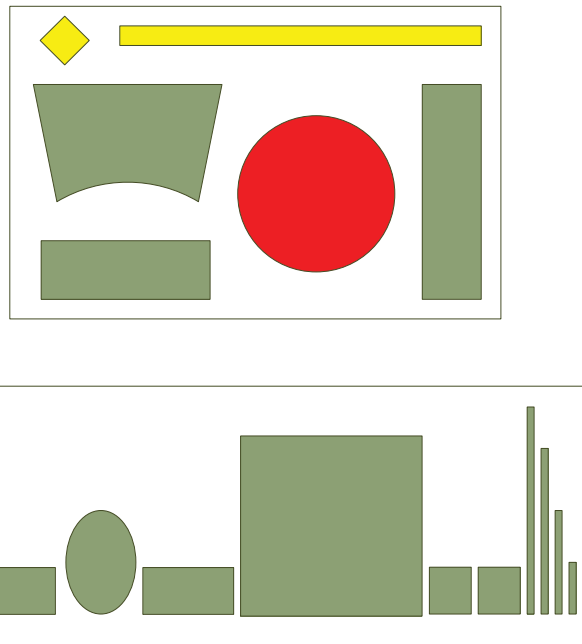


Figure 28. Two methods of leading the viewer through a poster: numbers, arrows.

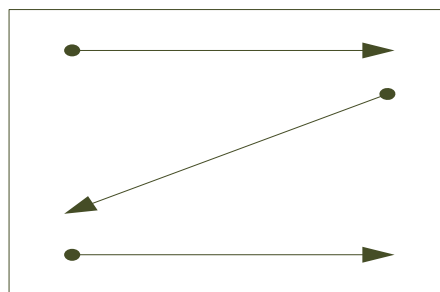




**Figure 29.** Attention-getting shapes.

### 10.3.2. *The title*

Use less and larger text to get the attention of the first glance of a potential reader. The title letters should read from about 4 to 5 m, 2.5 to 5 cm of height, bold and preferably solid-block. Fonts such as Times New Roman or Comic Sans are very often used. Avoid script, casual, fancy, and flowery fonts such as Brush Script MT, Gigi, Lucida Calligraphy, Jokerman or Poor Richard. Make the font size between 96 and 120 points. The title should convey the “issue” of the poster, with a maximum length of 1–2 lines, justified according to personal preferences and space constraints. The title can even be a bit provocative. This top part must contain the name(s) of the author(s), the institutional affiliation(s), city name(s), countries, and the poster number. Use abbreviations, first and middle initials, logo or personal photo if space permits.



**Figure 30.** Reading direction.

### 10.3.3. Section headings

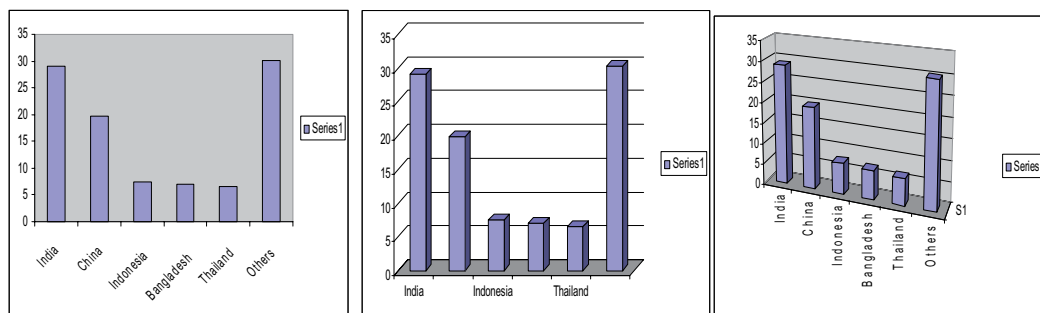
Clear, short, and informative headings attract people. Section headings summarize your work and convey the reader through the main points. Having subtitles helps to lead the readers more effortlessly through your poster.

Section headings should eventually be capitalized, centered, and double spaced from the lines above and below, eventually underlined or differently colored. There should be uniformity among all headings and subheadings. The section header font size should be 50–75% larger than the body text and approximately between 36 and 72 points.

### 10.3.4. Graphs

Graphs are the best way to present numeric patterns. They communicate relationships quickly. Knowledge transfer occurs easier with graphs than with tables. Graphics are mainly used in the result sections. There are different types of graphs: e.g., bar graphs, line graphs, and pie charts. Bar graphs are used to put up large groups and many variable data. Bar graphs are recommended if you like to show the proportion of each subject of a whole. Line graphs are very useful for displaying changes over time. This type of graph can accommodate several sets of data. Pie charts are good for presenting percentage ratios and for making a comparison of many series.

Graphic images should be kept simple and clean without tempting to present all data into one mega histogram. Show only the major findings or comparisons in 3 or 4 lines on a line graph or categories on a bar graph. For multivariate analyses, the results should be presented with main variables of interest, disclosing the other variables in the model in a footnote and including complex statistical tables in a handout. Emphasize data points and minimize the connecting lines. Apply practically distinctive bars and limit the size of borders. Use contrasting colors or patterns for adjacent sections. Labels, legends, and scales should be legible from 2 m. Stick to simple two-dimensional line graphs, bar charts, pie charts and avoid three-dimensional graphs (**Figure 31**) unless you are displaying three-dimensional data. Provide each chart with a title and accompany it with a few annotations. Generate chart types according to the expected audience and remember that you can flesh out descriptions of charts and tables in your script rather than including all the details on the poster itself. Do not present and repeat the same data in both a table and a chart.



**Figure 31.** Comparison between 2D and 3D bar charts.

### 10.3.5. Pictures and Visuals

A good illustrated poster with a minimum amount of text material looks always better. Try to hold about 40% empty space and divide the rest equally between illustrations and text. Illustrations should be visible easily from a minimum distance of 2 m. Overuse of different colors is not welcome. Illustrations are numbered separately and in the sequence that they need to be read.

Pictures of high quality break up the monotony of the text and graphs artistically inform the audience and clarify subjects, methods, field trials, and findings. Images must be small, clear, good colored, and contrasted so that a reader will immediately understand what is being shown. The smallest sufficient size of pictures to be visible from a distance is 10 × 15 cm. However, 13 × 18 or 18 × 24 cm pictures are preferable. Drawings are best if they are at least 18 × 24 cm. Use contrasting letters on the pictures as it is frustrating for the viewer to search for letters that appear camouflaged. If your pictures are digital images, use sufficient resolution to allow details to be seen at a distance. Digital images cannot be enlarged to any size without causing image degradation.

### 10.3.6. Text

The most effective posters provide an extremely concise, legible, and easily comprehended text. Do not overload the audience with masses of tables and data. Quantitative data can be presented as charts or drawings. Text should be simple, direct, and large, and visible from 1.5 to 2 m. Maintain a dark, good contrast text. Do not use a background with a design (e.g., an aerial view of your institute); but rather a white background. Do not print titles or headings in caps, use mixed upper and lower case text, avoid ornate or italic fonts. Note, that a poster is mainly an advertisement, not an article. Abridge the poster text up to 250–350 words. Limit yourself to 35–45 letters per line and no more than 4–8 rows per paragraph. Use left alignment that makes the text seem more alive and easier to read while standing. Justified text should be avoided. Use the active voice when writing the poster.

### 10.3.7. Font

Font types and sizes need to be effective so that readers do not walk away. Use a variety of font sizes for each section of your poster:

- Title: 96–120 pt.
- Author(s): 72 pt.
- Affiliation(s): 36–48 pt.
- Section headings: 36 pt.
- Text: 24 pt.
- Acknowledgements: 18 pt.

A good type of font is Times New Roman, Sans Serif, Courier, or Comic Sans.

10.3.8. Color

Color can attract attention, emphasize the hues or make a pizza of your poster. If you use multiple colors, use them in a consistent pattern. Use neutral and light background tones to enhance or reduce visuals and pictures. Print dark color letters on paper. Try to consider people who have problems differentiating colors. The color should not outclass the visual impact of your data.

10.4. Suggestions for improving your poster

Posters are often judged for their content as well as for their appearance. You must take care of main details which improve or disapprove the poster. Do not use too much text.

Do this ...	... not this
<ul style="list-style-type: none"><li>• The layout has about 20% text, 40% graphics and 40% empty space</li><li>• All letters are big and differentiated according to position and section</li><li>• Pictures, figures, and illustrations dominate visually</li><li>• Headings, text, and graphic elements are large to be visible from 2 m</li><li>• Background is absent but sections are divided hierarchically with blocks, columns, and sizes of text</li><li>• The poster is supplied with cues to help readers follow your presentation</li><li>• The poster is broken up into sections, much like a scientific article</li></ul>	<ul style="list-style-type: none"><li>• There is too much text in the poster</li><li>• Text printed uniformly with small letters of about 10–12-point font</li><li>• - Visuals are on a dark background and take place in a random way</li><li>• All text and graphic elements are run into each other and are small, that does not allow to be legible or have a good look</li><li>• Background too bright or too dark, the text in one block is light</li><li>• Very difficult to identify the most important parts of the poster and the viewers have no idea of organizational flow</li><li>• The poster is as one long, meandering thread</li></ul>

10.5. Poster session

Poster sessions advertise your research to the scientific audience. This usually takes place in the exhibition hall, corridor, large room, several small rooms, and other places. During the session viewers walk along the posters, they throw a glance and study information and discuss it with you. Sometimes they ask you to give a short presentation on your investigations. This session is designed to facilitate more in-depth discussion of the research than is typically possible in a symposium format. Please follow the directives of the conference for the timing of your presence at the poster. Your poster should be mounted before the session is scheduled and removed from the board after finishing. The poster discussion is usually running after a plenary session. It allows for stretching out during 60–90 minutes, but the posters will be available before the next meeting.

Organizers of conferences often inform the poster writers about the kind of audiences: experts and scientists, general, or mixed. If one asks the organizers what kind of posters they expect,

one can shape one according to their requirements. This helps you score a success by the audience. The poster session audience varies according to the kind of conference you are attending.

You may have only a short time to set up your display, so check the conference/symposium guidelines to know what specific materials you need to prepare. Many of these supplies can be purchased at the conference: string (3 m), box with longer and thicker push-pins than standard push-pins, dressmaker's pins, double-faced tape, rubber cement, dry mounting tissue, glue stick, scissors, etc. The poster elements can be fastened to the foam board without visible attachments, or can be attached with pins or with double-faced tape.

The author should stand directly in front of the poster during the session. Ask somebody to take a picture with your poster. Get some space free for the readers and do not ignore questions of participants of the conference, workshop, or symposium. While the attached poster is discussed, you may provide the audience with handouts, business cards, and sign-up sheets to record the names and addresses. Put them nearby, on a table or in an envelope hung with the poster and restock them periodically. At least 50 copies should be available for distribution. Display a copy of your abstract to give to the viewers. People should remember you and your work!!

## Author details

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## References

List of references and reading material

Note the following points about the references in the text:

- a. this list of references contains consulted literature to the text in the different chapters;
- b. this list contains also references as examples for different types of documents (see the list on Section 5.2.); therefore, they are numbered; and
- c. the used system is not linked to any specific journal; it is, however, a system quite universally used.

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The “Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural, and Life Sciences” is meant to be a practical guide for the preparation of theses, papers, posters, and other scientific documents. Upon going through the different chapters, the readers should be able to critically search for relevant literature; to correctly define and execute a research topic or project; to correctly write a scientific document; to know the characteristics of the different parts of a MSc degree or PhD degree thesis and a scientific paper; to correctly interpret publishing ethically sensitive material; to understand problems about falsification, fabrication of data, plagiarism, and ranking of authors; and to prepare and present a good poster.

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