**Lecture 5 «Writing a scientific research article and report»**

The process of academic writing should not be molded from technical clichés or reduced to a list of tips and tricks in targeting an easy publication. This brief contribution does not impose some strict rules on the scholarly publications but rather assists the prospective authors in preparing and improving their review articles in a way that is deemed beneficial to a wide academic audience.

Note that the adjectives “academic” and “scholarly” used above are synonyms and can be used interchangeably, thus indicating that submitted manuscripts would be a subject of peer review.

There are two types of scientific articles: review articles and primary research articles.

**Review articles** give an overview of the scientific field or topic by summarizing the data and conclusions from many studies. These types of articles are a good starting place for a summary of what has been happening in the field. And they often contain more background information than primary research articles do, which means if at any point you're confused while reading the primary literature, it will help to go back and look at reviews. It is also wise to read several reviews by different authors for a well-rounded perspective of the field; individual authors have their own biases and you want to make sure you're exposed to as many different points of view as possible before you settle on your own conclusions.

Review articles of good quality are frequently needed in the presence of the growing number of research papers. A review article is expected to provide a summary and/or a synthesis of the findings of selected research contributions being published by other authors. The main purpose of a review article is to examine the current state of the relevant publications on a given topic and to initiate a discussion about the research methodologies and the findings related to the said topic.

Therefore, a review article should contain a comprehensive list of supporting references being thoroughly cited in the text.

The structure of a review article may differ from the structure of a regular paper due to the optional omission of some basic sections such as: Introduction, Analytic Model, Materials and Methods, Results, or Discussion. Sometimes it is difficult to classify a paper submission as a review article, a regular paper, or just a comment after noticing the combined use of an extensive literature review, original research contributions, and specific comments concerning only a few cited papers.

Then the authors may receive review reports on case by case basis suggesting a modification of the script or its eventual separation into at least two contributions. Although there is no strict limitation concerning the review topics, it is preferable that even narrow focused contributions are being written from a more general perspective which would only benefit the authors with an eventual increase of the number of citations referring to their articles.

It is recommended that the publication type: Review/Overview, Critical Review, etc…, should appear in both the title and the abstract of the article. A brief description of some of the publication types is provided below.

Review articles can be loosely classified into two basic types, non-systematic and systematic ones. The non-systematic type may include a selection of a wide range of technical results related to a chosen topic which reflects the professional experiences and interests of the authors. The quality of such papers depends on the competency and the sincere efforts of the authors to provide a good review of the subject matter. The systematic type requires an advanced preparation and relies on a specific methodology being chosen in advance, where selected foundation studies are being analyzed in connection to a long-standing problem statement.

Despite the various levels of complexity of the technical topics, the review articles are limited in including analytical and experimental parts from cited papers. The amount of text should be well balanced with the number of figures so that the addressed issues are clearly stated in a simple and efficient way. The real challenge here is in transforming a collection of technical information into a coherent script which provides an alternative point of view on previously unknown or not well understood relations among distinct studies. One should seek a proper balance between the levels of differentiation and integration of different aspects of technical information as well as between the statistical analysis of experimental data and its theoretical interpretation, etc. The review articles have to provide forums for further discussions about the problem statements and not just summarize the peculiarities of each cited paper but rather transform the presented information into an inspirational material for future studies.

**Critical Reviews**

The critical reviews supposedly analyze the strengths, weaknesses, and open questions of a research paper after studying its problem statement and scientific content. The critical reviews should properly describe, then analyze and finally discuss the research findings which would hopefully result in a critical evaluation and a resultant constructive interpretation of the selected paper.

The critical reviews must be based on verifiable scientific facts, logic and reasoning but not on inconclusive arguments or personal interest. The technical criticism should be presented with a scholarly level of tolerance and understanding. Open-minded approach is recommended for the prevention of plain debunking.

**Article Reviews**

The article review is based on the choice of a single publication on technology and its fair evaluation. The following preparatory sequence can be used as a rule of thumb: read carefully the chosen article, list the technical issues of concern, prepare a draft version, consult with colleagues, perform at least one revision prior to submission.

**Surveys**

The surveys are useful and successful if they address an important technological topic being at the focus of a large part of the scientific community and the authors have in depth understanding on the field of research as well as a full access to all the relevant materials to be cited. Surveys usually contain an extensive literature review and a lot of technical details concerning different aspects of the scientific investigation. A literature review may cite a multitude of journal papers, books, theses/dissertations, conference proceedings, etc. However, such a literature review alone does not produce an entire survey which is actually quite a sophisticated script.

**Historical Articles**

Manuscripts on the history of technology and technology management are also invited for publication provided that the historical details and their interpretation are original and not previously published elsewhere.

**Book Reviews**

A book review may address one particular book or a series of books devoted to technology. It is preferable to reduce the analytical and graphical content and concentrate on the discussion about the valuable information which can be derived from the book chapters. In case of a research monograph, where distinct chapters are written by different authors, elaborate on both the self-consistency and the overall writing style.

**Primary research articles** contain the original data and conclusions of the researchers who were involved in the experiments. These articles also contain details about how the experiments were done. Or, in the cases of some journals, they might contain web addresses for "supplemental data" found online, which detail the methods used by the authors. In general, primary research articles should be consulted any time you need to get more information about how an experiment was carried out, or if you need to review the original data, which you may want to do in order to base your experiments off their data, or to evaluate for yourself the validity of the authors' conclusions. Primary research articles are also useful for seeing how experts in that scientific field visually represent their data. For example, what types of graphs are common to the field? Are there any specific units that are used? You'll eventually need to know this information to put together a good report or display board to convey your research.

If you're looking at a paper and you're not sure if it is a review or a primary research article, here are a few easy ways to distinguish. First of all, many reviews will be labeled as "review" or "tutorial" on the first page of the article. Also, reviews don't have a "methods" section (although you *can* find entire reviews dedicated to discussing the advances in a specific method or technique). And in a review article, graphs, tables, or figures containing actual data will contain citations in the figure legend to the primary research papers that originally reported the findings.

Primary research articles are typically broken down into ***six sections:*** abstract, introduction, materials and methods, results, discussion, and references. A few journals have slightly different formats due to their space constraints or target audience. The most common alteration is to combine the results and discussion parts into a single section. Each part of the paper serves a unique purpose and can help your research project in a different way.

**Abstract**

The abstract is a summary of the paper. It usually highlights the main question(s) the authors investigated, provides the key results of their experiments, and gives an overview of the authors' conclusions. Reading the abstract will help you decide if the article was what you were looking for, or not, without spending a long time reading the whole paper. Abstracts are usually accessible for free either online at journals' websites or in scientific literature databases.

**Introduction**

The introduction gives background information about the topic of the paper, and sets out the specific questions to be addressed by the authors. The quantity and thoroughness of the background information will depend on both the authors' proclivities, and the guidelines for that specific journal. Throughout the introduction, there will be citations for previously published articles or reviews that discuss the same topic. Use these citations as recommendations for other articles you can refer to for additional background reading.

Reading the introduction is a test of whether or not you are ready to read the rest of the paper; if the introduction doesn't make sense to you, then the rest of the paper won't either. If you find yourself baffled by the introduction, try going to other sources for information about the topic before you tackle the rest of the paper. Good sources can include a textbook; online tutorials, reviews, or explanations; a review article or earlier primary research article (perhaps one of the ones cited in the introduction); or a mentor. If even after trying all these sources you're still confused, it may be time to consider a new topic.

**Materials and Methods**

The materials and methods section gives the technical details of how the experiments were carried out, including the types of controls used and where unusual resources (like a bacterial strain or a publicly available data set) were obtained. Reading the methods section is helpful in understanding exactly *what* the authors did. After all, if you don't understand their experiments, it will be impossible to judge the veracity of their results and conclusions! This section also serves as a "how-to" manual if you're interested in carrying out similar experiments, or even in repeating the same experiments as the authors did.

The materials and methods section is most commonly placed directly after the introduction. But if you can't find it there, check the end of the paper, just before the references, or look for a URL within the research article for a "supplementary information" section online.

**Results**

The results section is the real meat of a primary research article; it contains all the data from the experiments. The figures contain the majority of the data. The accompanying text contains verbal descriptions of the pieces of data the authors feel were most critical. The writing may also put the new data in the context of previous findings. However, often due to space constraints, authors usually do not write text for all their findings and instead, rely on the figures to impart the bulk of the information. So to get the most out of the results section, make sure to spend ample time thoroughly looking at all the graphs, pictures, and tables, and reading their accompanying legends!

Three types of information can be extracted from the results section: data from the experiments, ideas about how to improve the methods, and an understanding of how to represent similar data. Clearly, this is the section of the paper you refer to if you need to know exactly what the researchers found out, particularly if you need data to compare with your own findings, or to use to build your own hypothesis. The results section is also useful for understanding whether the methods of an experiment worked well. For example, a graph of the data might show that although the authors took time points every hour, there was no change at all until five hours into the experiment, and then the change was rapid. By interpreting their graph yourself and making this observation, you would be able to repeat the experiment, with differentially spaced time points, to resolve what actually happened during the fifth hour. And last, but not least, studying the figures will help you understand how to represent your own data in a way that is clear, accurate, and in keeping with the standards in that particular field of science.

**Discussion**

The discussion section is the authors' opportunity to give you their opinions. It is where they draw conclusions about the results. They may choose to put their results in the context of previous findings and offer theories or new hypotheses that explain the sum body of knowledge in the field. Or the authors may comment on new questions and avenues of exploration that their results give rise to. The purpose of discussion sections in papers is to allow the exchange of ideas between scientists. As such, it is critical to remember that the discussions are the authors' interpretations and not necessarily facts. However, this section is often a good place to get ideas about what kind of research questions are still unanswered in the field and thus, what types of questions you might want your own research project to tackle.

**References**

Throughout the article, the authors will refer to information from other papers. These citations are all listed in the references section, sometimes referred to as the bibliography. Both review articles (often cited as "reviewed in...") and primary research articles, as well as books or other relevant sources, can be found in the references section. Regardless of the type of source, there will always be enough information (authors, title, journal name, publication date, etc.) for you to find the source at a library or online. This makes the reference section incredibly useful for broadening your own literature search. If you're reading a paragraph in the current paper and want more information on the content, you should always try to find and read the articles cited in that paragraph.