Research Methodology and Scientific Writing (Chem 453)

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Background

Research methodology and Scientific Writing in science is a course designed to acquaint the learners (here, the Summer-In-Service Candidates) with the basic knowledge necessary to execute research, write research findings and communicate the findings (orally, in written form, or poster) to end user. Moreover, it aware the learners with the basic rules, rights and obligations of individuals involved in research and scientific paper writing.

Course Objectives

Upon completion of the course, the students will be able to:

- identify research problems and write sounding research proposal
- have good knowledge of various research types and research methodologies applied in science.
- design field and laboratory data collection methodologies
- describe the hierarchy of the scientific literature review
- differentiate primary and secondary out comes
- identify the methods used in presenting scientific results in dissertations and scientific journals
- prepare a review paper
- develop skill of poster preparation and presentation
- present research results in oral and poster form to professionals and nonprofessional audience.

Unit 1 Introduction

Unit Objective

After completing this unit, you should be able to:

- Distinguish the difference between the two sources or approaches knowledge (commonsense vs. science/ everyday observation vs. planned observation)
- Differentiate between inductive and deductive reasoning
- Define what a research means
- Explain the purpose of research
- Classify research into different types based on different criteria
- Distinguish the differences between basic and applied research

Unit Introduction

In this unit, you will deal with the two major approaches of knowing the world: everyday experience and science. It answers questions like what is the difference between common sense knowledge and science? Are they alike? What are the various forms of knowing? It will be followed by definition of research with elaboration on the purposes of conducting a research, approaches and goals of research. Distinction has also been made between terms like methods and methodologies. Finally, the unit will attempt to introduce the classification of research.

1.1 Everyday experience as a source of knowledge

Dear learner, as we live in this world and interact with our surrounding we may be confronted with new ideas that may have important impact on our lives. We get access to this new information through our senses- the most immediate way of knowing something. This is what we call sensory knowledge. Reflecting on your own experiences, do you think your senses provide a perfect means of observation?

We may also use the opinion of others as a source of knowledge. We might have experienced a stimulus with our senses but we want to check on the accuracy and authenticity of these sensations. We often ask:

- Does this food taste delicious to you?
- Did you hear someone crying for help?

Activity 1

Did you rely on your senses and trust the data you collected, because it has been said, "seeing is believing"? How reliable is your senses?
Do you think that a majority opinion defines true?

There are also other ways of knowing from our every day experiences. These are presented below.

1.1.1 The method of tenacity

The term tenacity refers to the acceptance of a belief based on the idea that "**we have always known it to be this way**". In other words it represents the automatic acceptance of the prevailing traditional believes and customs in which we have been socialized. We accept those beliefs and customs as true without exploring them and then behave with it. Even when we come across evidences that contradict our beliefs, we still tend to cling to our traditional belief.

As a way of learning about the surrounding world the method of tenacity has two problems:

1. The information may gain wide acceptance through its familiarity alone.
2. Tenacity offers no means of correcting erroneous ideas.

Activity 2

Is darker color injera more nutritious?

Give two examples of the general beliefs that you have accepted without evaluating them. For instance, in some cultures Female Genital Cuting (FGC) is an accepted practice.

1.1.2 The method of authority

If we enter into a new culture, we may experience so many things for which we are not familiar. If we are naïve to most of the practices what we do, we ask someone in that culture who is supposed to have the knowledge-an authority figure. We are likely at aske others whom we think have a wealth of experience and knowledge about the cultural practices of the community. We may, then, accept a new idea or information stated by this authority figure.

In many cases, referring to an authority, especially in areas about which we know nothing, is useful and beneficial. We often rely on the judgment and expertise when we consult, for example, electrician, civil engineer or chemist.

Remember that authority can be incorrect and at times can lead people in the wrong directions. Hence, it is important to examine the basis of the authority's claims. We have to raise questions like, are these claims based on opinion, tradition, or direct experience? How valid are the sources of this information?

Activity 3

In our day-to-day living we accept what we have been told by an autority figure, for example a physician may tell us that smoking affects our health.

1. List examples that can be explained in terms of the method of authority.
2. Is everything published in a newspaper or book always true and accurate?
3. Is there a problem if we unquestioningly accept the knowledge and expertise of others?

1.1.3 The a priori method

The idea that underlies the a priori method is that first we develop general knowledge, opinion, or belief about the world through the aforementioned methods or personal observation of things around us and we draw new and specific conclusion from this general knowledge. As a result it is also known as a deductive reasoning. Our intellect allows us to use sensory data to develop a new kind of knowledge.

Reason and logic are the basic tools of an a priori method and often take the form of a logical syllogism such as ***All men are tall; Alemu is a man; therefore, Alemu is tall.*** Hence, logical conclusions may not necessarily lead to correct conclusions. We all use reason everyday as we try to solve problems and understand relationships. As useful as it is to be reasonable, however, reason alone will not always produce the appropriate knowledge.

Activity 4

Draw your own syllogistic conclusion: Ethiopia has the best long distance runners in the world. Mosisa is an Ethiopian, therefore… Does this conclusion always holds true?

1.1.4 Common sense

This method of knowing offers an improvement over acceptance based on tenacity, authority, or reason because it appeals to direct experience. Common sense is based on our own past experiences and our perceptions of the world. It originates from our day-to-day practical experiences and in turn guides our daily interaction with our surrounding.

Dear learner, note that our experiences and perceptions of the world may be quite limited. The concepts that we have about the world may be seriously misleading. Although common senses may help us deal with the routine aspects of daily life, it may also form a wall and prevent us from understanding new ideas.

Activity 5

Where would it be more appropriate to apply common sense: knowing what will happen to the price of teff when the rainy season fails, or knowing how bacteria respond to a new type of drug?

1.2 **The scientific method as a source of Knowledge**

Science is a body of systematized knowledge. In scientific method ideas are evaluated and corrected through dispassionately observing by means of our bodily senses or measuring devices-in this case science can be seen as a systematic and controlled extension of common sense- and using reason to compare various theoretical conceptualization based on experience – which represents a direct application of the principle of logic. This blend of direct sensory experience (or measurement) and reason gives science a self corrective nature.

Dear learner, one of the characteristics of science is a reliance on information that is verifiable through experience. That is, it must be possible for different people in different places and at different times using the same method to obtain comparable results.

Science and common sense differ in terms of:

- the use of conceptual scheme and theoretical structure
- the notion of control
- the explanation of different observed phenomena

The difference between common sense and science revolves around the concepts of **systematic and controlled.** Scientists systematical build theoretical structures, test them for internal consistency, and subject aspects of them to empirical test.

The scientific method of knowing is the scientific research, and its goal is discovery of regularities of nature and their representation in theories from which predictions can be made.

The steps in the scientific method guide researchers in planning, conducting, and interpreting research studies. Scientific research follows logical steps, which include:

- defining the problem
- making tentative explanations
- gathering information
- testing the validity of the hypothesis
- making conclusions as to whether the hypothesis can be accepted or rejected

Scientific methods:

- find general rules,
- collect objective evidences,
- make testable statements,
- adopt a skeptical attitude about all claims
- are creative
- are public, and

- are productive

Dear learner, it should be noted that, apart from its importance in knowing the world, the scientific method of knowing has some limitations.

- The scientific method cannot answer all questions
- Application of scientific method can never capture the full richness of the individual and the environment
- The measurement devices always have some degree of error.

Activity 6

What is the difference betweeen common sense and science?

What are the steps that people should follow in scientific methods of knowing?

What are the strengths of scientific method?

What are the limitations of scientific method of knowing?

1.3 **Definition and purpose of research**

Dear learner, in this section the concept of research is defined and the purposes and goals of research are described.

1.3.1 **Definition of scientific research**

Research is the systematic process of collecting and analyzing information to increase our understanding of the phenomenon under study. It must be systematic and follow a series of steps and a rigid standard protocol. Scientific research must be organized and undergo planning, including performing literature reviews of past research and evaluating what questions need to be answered.

The main characteristics of scientific research can be summarized as follow. Research:

- is directed toward the solution of a problem;
- is based upon observable experience or empirical evidence;
- demands accurate observation and description;
- involves gathering new data from primary or first-hand sources or using existing data for a new purpose;
- is characterized by carefully designed procedures, always applying rigorous analysis. However, it is sometimes random and unsystematic;
- requires expertise;
- is characterized by patient and unhurried activities;
- is carefully recorded and reported;
- sometimes requires courage;
- emphasizes the development of generalization, principles or theories that will be helpful in predicting future occurrences; and
- strives to be objective and logical, applying every possible test to validate the procedures employed, the data collected, and the conclusion reached.

1.3.2 **Goals of scientific research**

The purpose of scientific research is problem solving. The problem could be of an immediate and practical value or they could be of theoretical nature. That is, research focuses on answering various questions and acquiring new knowledge. It is the primary tool used in virtually all areas of science to expand the frontier of knowledge. In addition, by conducting research, researchers attempt to reduce the complexity of problems, discover the relationship between seemingly unrelated events, and ultimately improve the way we live.

Research can be used for the purpose of description, explanation, prediction, and control all of which make important and valuable contributions in solving practical problems and also in the expansion of what we know and discovery of new knowledge.

Description: represents efforts exerted to give pictorial account of the phenomenon being studied.
Example: a researcher may describe that water in a solid state have lower density than that in a liquid state.

In description the researcher attempts to find answers to the questions "what," "who," and "where?"

Explanation: in explanation, the researcher is interested in exploring the reasons or the causes of the occurrence of certain behavior or event. It involves understanding the cause – and – effect relationship between phenomena. Attempts have been made to answer the question "why?"

Example: Why does ice have lower density than water?

Prediction: in research, generalization is made not only to explain the past but also to predict what will happen in the future.

Example: Females empowerment improves their level of participation in politics.

Control: researchers are also interested in influencing or changing a particular event or condition for different purposes. Therefore, the description, explanation, and or prediction of events which, result from any research undertaking, are not casual or without aim. It is to explore and allow possibilities of control – to intervene and subsequently observe an expected result.

Comparison: the researcher may also be interested in comparing two or more groups on certain behavior. The purpose here is to explore whether two or more groups are similar or different with respect to the occurrence of certain event. Comparison may also take different forms. Instead of comparing groups on one behavior, the researcher may instead

compare different behaviors in one group simply to determine which behavior is more likely to occur in this same group of individuals.

Example: is there gender difference in terms of level of participation in politics?

1.4 **Types of research**

Dear learner, in this module we use the following ways of classifying research only for the purpose of illustrating how research is classified. Research can be classified in terms of:

- goal of research,
- specific objective of research,
- approaches of research,
- designs,
- the type of data used in research, and
- fields of study.

1.4.1 **Classification of research based on the goal of research**

Dear learner, as you will recall, it has been mentioned in section 1.3.2 that the goal of research is problem solving. The nature of the problem that the researcher attempts to solve could be theoretical or practical-building a theory or solving immediate practical problems. These two types of problems that the researcher tries to solve leads to two broad classifications of research:

- basic research, and
- applied research,

1.4.2 **Classification of research based on the specific objectives of research**

From your knowledge of section 1.3.1, research also addresses specific purposes. Your interest could be describing a phenomenon of interest or explaining casual link between

two variables. Or you may be interested in comparing two or more groups on the basis of particular phenomenon. Research, therefore, can be classified differently when the issues at hand are specific objectives of research. Hence, according to the specific objectives research can be classified as:

- descriptive,
- explanatory,
- exploratory

1.4.3 **Classification of research based on approaches research**

Research can be classified as qualitative research and quantitative research when the issue at hand is the approaches to be employed in conducting research.

1.4.4 **Classification of research based on designs**

Another way of classifying research is by design. Once the researcher has determined the specific question to be answered and has operationalized the variables and research questions into a clear, measurable hypothesis, the next task is to consider a suitable research design. Although there are endless ways of classifying research designs, they usually fall into one of three general categories:

- experimental,
- quasi-experimental, and
- non-experimental

1.4.5 **Classification of research by type of data**

Depending on the type of data generated and used research can be classified as Primary research (also called field research) and secondary research (also known as desk research). Primary research involves the collection of data that does not already exist whereas secondary research involves the summary, collection and/or synthesis of existing

data rather than generating primary data, where data are collected from, for example, research subjects or experiments.

1.4.6 **Classification of research by field of study**

Research can also be classified based on fields of study. Therefore, there are:

- natural science research,
- social science research,
- educational research,
- behavioral science research,
- health science research, etc.

Activity 7

What is the difference between natural science research and social science research?
Describe the difference between descritive and explanatory research?
How do choose a particular type of research?

1.5 **Basic and Applied Research**

Basic research (also called *fundamental or pure* research) is experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than the advancement of knowledge. Thus, it is exploratory and often driven by the researcher's curiosity, interest or hunch. It is conducted without a practical end in mind although it can have unexpected results that point to practical applications.

Basic (*fundamental* or *pure*) research is driven by a scientist's curiosity or interest in a scientific question. The main motivation is to *expand man's knowledge*, not to create or invent something. There is no obvious commercial value to the discoveries that result from basic research. For example, basic science investigations probe for answers

to questions such as: How did the universe begin? What are protons, neutrons, and electrons composed of? How do slime molds reproduce? What is the specific genetic code of the fruit fly? At what point in human history did logical thought arise? Are living organisms the rule or the exception? What is the mind-body connection?

There have been many historical examples in which basic research has played a vital role in the advancement of scientific knowledge. Here are just a few important examples:

- Our understanding of genetics and heredity is largely due to the studies on plants in the 1860's by G. Mendel, and the experiments with fruit flies in the early 20th century by T.H. Morgan.
- Many of today's electrical devices (e.g., radios, generators and alternators) can trace each conducted by Michael Faraday in 1831. He discovered the principle of electromagnetic induction, that is, the relationship between electricity and magnetism.

Thus, applied research is designed to solve *practical problems* of the modern world, rather than to acquire knowledge for knowledge's sake. One might say that the goal of the applied scientist is to improve *the human condition*. For example, applied researchers may investigate ways to: improve agricultural crop production, treat or cure a specific disease, improve the energy efficiency of homes, offices, or modes of transportation.

An Applied Microbiologist, for example, could evaluate microorganisms for their possible application in the production of useful industrial product, antibiotics, improving soil fertility, use in food or beverage industry, etc. Here, the target of the research is not mere characterization or description of the microbes to know their biology, rather for their use to solve a particular problem to satisfy societal needs. Applied research is often carried out by academic or industrial institutions. More often an academic institution such as a university will have a specific applied research program funded by an industrial partner. Common areas of applied research include electronics, informatics, computer science, and process engineering and applied sciences.

In general, basic research:

- Represents a rigorous and structured type of analysis;
- Employs careful sampling procedures in order to extend findings beyond the group or situation; and
- Has little concern for the application of the findings or social usefulness of the findings; whereas;

Applied research:

- Is conducted in relation to actual problems and under the conditions in which they are found in practice;
- Employs methodology that is not as rigorous as that of basic research;
- Yields findings that can be evaluated in terms of local applicability and not in terms of universal validity.

Activity 8

Is there commercial value involved in the discoveries that result from basic research?
When do we use basic research?
When do we use applied research?

Unit end exercises (Assignments)

1. List the everyday source of knowledge and give examples for each of these sources of knowledge.
2. What are the limitations of using everyday experiences as a source of knowledge?
3. Why is the scientific method is superior to any other sources of knowledge?
4. Describe the limitations of scientific method by giving at least one example
5. Which of the two types of research (basic or applied) will be the focus of your

graduation project?

6. Classify the following research topics as pure or applied

    a. Silicon chips as the major component of computer

    b. Investigation of X-rays

    c. production of plastic bags from starch

    d. element 114 confirmed

Unit 2 Steps in scientific research

Unit objectives

At the end of this unit, you should be able to:

- identify a research question that will help you to develop proposal,
- formulate hypothesis for proposed research question,
- review relevant literature that strengthens the research question,
- use different source of information
- identify the components to be included in the methodology section of your proposal,
- identify an appropriate study design for a research,
- determine suitable data collection techniques for your study,
- identify the important points to be considered when starting to plan for data collection,
- decide on the important data analysis methods for your proposed research,
- properly outline a work schedule and budget cost for a proposed research
- write scientific papers (articles, thesis, dissertations, etc)
- present scientific reports (oral, poster, etc)

Unit overview

The unit is designed in a way that it guides you to the actual practice of writing a research proposal enabling you write a research proposal at the end of the course. At each section of the unit, you will develop fragment components of a proposal to be finalized with full coverage of components of typical proposal. The latter part of the section deals with how to write and present scientific papers. This helps you to develop skills of organizing your research data to be communicated to the scientific community. Thus, with completion of each section of the unit, you will be equipped with additional tips and knowledge that will help you to develop sound proposal and write scientific paper with full confidence of presenting the research outputs.

2.1 **Problem identification and developing research title**

Section objectives

At the end of this section, you should be able to:

- Identify chemical research problems,
- Set criteria for prioritization of research problems,
- Apply the selected prioritization criteria on a number of research topics,
- Select an appropriate topic for a research proposal that you are going to develop in partial fulfillment of the course ,
- Elaborate the concept of hypothesis,
- Develop hypothesis for your research question to be formulated during the course,
- Differentiate and develop null and alternative hypothesis for your research problem,
- Develop a skill of literature searching

Section introduction

In this section, you will learn about the concept of problem identification in a research project. Then, the importance of problem identification and definition of problems will be discussed. Finally, criteria to be used for prioritization of research problems will be given due emphasis and information to be included in the selected research problem will be elaborated. Moreover, discussion will be made on the concept of hypothesis, nature of hypothesis, the need to develop a research hypothesis, and types of hypothesis will be briefed. In addition, the procedure or techniques of how to utilize academic library will be discussed.

2.1.1 **Problem identification**

Problem identification is a process of research topic selection. The topic to be investigated can be obtained from different sources. One of the most common sources of research ideas is the experience of practical problems in the field. Another source

for research ideas is the literature in a specific field. Certainly, many researchers get ideas for research by reading the literature and thinking of ways to extend or refine previous research.

In addition, the source of research problems/topics could be:

- Research interest of a professor/mentor,
- Discussion with earlier graduates,
- Researcher's professional experience and interests,
- Current issues in sciences

Once the research problem is identified, it must be formulated as a question that the scientific method can answer. Moreover, the identified research problem should be specific, and achievable. In general, it needs to be SMART.

Dear learner, look at the following examples; it begun with non-question and gradually developed into a well formulated research question.

Non-question: Climate change affects plant distribution. This statement is a general fact. When this statement is changed into a question, it can have the format of either of the following questions:

1. *Does climate change have effect on plants distribution?* (Poorly formulated question)

If you examine this question, it seems a research question as it is written in the form of question that will be answered at the end of the study. However, it has some limitations. It is neither specific nor achievable. Here, assessing the distribution of all plant (non-specific) found on earth in relation to climate change is unthinkable (not achievable).

2. *Does climate change have effect on distribution of indigenous trees species of Ethiopia?* (Well formulated question). This question is example of well formulated research question. Because, the topic is specific, it deals with effect of climate change only on *indigenous* trees of Ethiopia. In addition, it is achievable although it needs intensive effort and requires collaboration of different expertise.

Activity 9

What is the relevance of stating and defining a research problem?

Does formulating a research question have any significance for a research activity? Please write down your possible answers on your note book. Then, compare your responses to the descriptions given below.

The following are among the purposes of stating and defining a research problem:

1. It is the foundation for the further development of the research proposal (research objectives, methodology, work plan, budget, etc.),
2. It makes easier to find information and reports of similar studies to be used while designing your study,
3. Enables you to systematically point out why the proposed research on the problem should be undertaken and what you hope to achieve with the study results. This is important to emphasize when you present your proposal to concerned bodies, community members, relevant ministries and donor agencies that need to support your study or those who will give their consent.

CHECKLIST to evaluate your research problem

Evaluate you research problem as per the checklist given below. Use √ mark against the questions.

1. Write a clear statement of a problem for research. ☐
2. Review your written statement and ask yourself the following questions:
   - Is the problem stated in a complete, grammatical sentence? ☐
   - Is it clear on how the area of study will be limited or focused? ☐
3. On the basis of your answers to the questions in #2, edit your written statement.
4. Look at your edited statement and reflect on the following questions: ☐

- Does the answer to this problem have the potential for providing important and useful answers and information?
- Will the result be more than a simple exercise in gathering information, answering a yes/no question, or making a simple comparison?
- Is the problem focused enough to be accomplished with a reasonable expenditure of time, money, and effort?

5. Look at the statement once more, consider this:
   Is the problem really what I want to investigate?
6. Show other research students your work. Ask them to consider the questions listed in items 2 and 4 and then to give you their comments. With your compiled feedback, edit and rewrite your problem statement once again.

2.1.2 **Criteria for prioritizing topics for research**

Each topic proposed for a research has to be judged according to certain guidelines or criteria before making decision. Each proposed topic must be compared with all other options. The following guidelines or criteria are suggested to help you in the process of selection of problem or research topic:

- Significance/ relevance
- Originality
- Urgency of data needed
- Acceptability of the study
- Practicability
- Applicability of results
- Ethical acceptability

Significance (Relevance)

A research question to be selected should be of serious problems that affect a great number of people or animals or of the most serious problems that are faced by population living

in your area. In addition, you have to consider the question of who perceives the problem as important. This is to ensure full participation of all concerned parties; it is advisable to define the problem in such a way that all have an interest in solving it.

Originality

Before you decide to carry out a study, it is important that you find out whether the proposed topic has been investigated before. If the topic has been researched, the results should be reviewed to explore whether major questions that deserve further investigation remain unanswered. If not, another topic should be chosen.

Urgency of data needed

How urgently are the results needed for developing interventions at various levels (from community to policy)? Consider which research should be done first and which can be done later.

Acceptability

It is advisable to research a topic that has the interest and support of the national authorities. This will increase the chance that the results of the study will be implemented and make the work smooth.

Practicability

When you choose a research topic you have to look at the complexity of the problem and the resources you will require to carry out your study. Thought should be given to manpower, time, equipment and money that are locally available. In situations where the local resources necessary to carry out the project are not sufficient, you might consider resources available at the national level; for example, in other research institutions, or local universities. Finally, explore the possibility of obtaining technical and financial assistance from external sources.

Applicability of the results

This is whether the findings of the study will be applied or not. It will depend on the researcher's capability and also on the availability of resources for implementing the result.

Ethical acceptability

You should always consider the possibility that you may inflict harm on others while carrying out a research. Therefore, review the study you are proposing and consider important ethical issues such as: cultural sensitivity, involvement of human subject in the study and possibility of getting consent from the research subjects and other related issues. (For further information on research ethics, refer to the section on Research ethic in unit dealing with Writing Review Paper).

2.1.3 **Prioritizing Topics for Research**

Once research problems are identified and formulated, the next step will be rating each research topic based on set criteria or guidelines. Priority setting is an important activity when resources are limited. Since it is difficult to conduct a research on every problems identified at once, researcher should set prioritization criteria. Then, rating or scaling each problem against the set criteria is mandatory. There are different types of rating:

- Sum of ranks method/modified
- Point allocation method.

The usual type of rating is point allocation method. In this type of rating, final score given for each item is determined by adding up points assigned for each topic. The topic that got highest mark could be considered as priority problem and then proposal will be developed to it.

Dear learner, closely examine the following scales given for each criterion (guideline) as suggested by Varkevisser *et al.*, (2003):

Relevance:

1 = not relevant; 2 = relevant; and 3 = very relevant

Originality

1 = sufficient information already available

2 = some information available but major issues are not covered; and

3 = no sound information available

Urgency

1 = not urgently needed;

2 = to less extent it is urgently needed; and

3 = data is very urgently needed for decision making

Political acceptability

1 = topic not acceptable;

2 = topic more or less acceptable; and

3 = topic fully acceptable

Feasibility

1 = study not feasible; 2 = study feasible; 3 = study very feasible

Applicability

1 = not applicable; 2 = some time can be implemented; 3 = highly applicable

Ethical acceptability

1 = major ethical problems; 2 = minor ethical problems; 3 = no ethical problems

Activity 10

Think of different problems that you want to consider as a research question for your senior essay and list them down. Based on the above criteria, prioritize and come up with the most urgent, relevant, applicable, feasible, original and ethically acceptable research problem.

2.1.4 **Developing null and alternative hypotheses**

Activity 11

Define hypothesis based on research project designing? Write your answer on your note book

Different experts defined hypothesis in different ways. For instance:

- Eric (1966) defined hypotheses as 'single tentative guesses, good hunches assumed for use in devising theory or planning experiments intended to be given a direct experimental test when possible.
- Macleod and Hockey (1981) defined hypothesis as it is a statement or explanation that is suggested by knowledge or observation but has not, yet, been proved or disproved.
- Ary, Jacobs and Razavieh (1984) defined hypothesis as 'a tentative proposition suggested as a solution to a problem or as an explanation of some phenomenon.'
- Sarantakos (1993) described hypothesis as a tentative explanation of the research problem, a possible outcome of the research, or an educated guess about the research outcome.
- Moreover, Creswell (1994) also defined hypothesis as it is a formal statement that presents the relationship between an independent variables.

Dear learner, from the above definitions, it is possible to summarize that *hypothesis is an educated guess, or a prediction of causal relationships that can be tested*; an unanswered question that arises from a literature review of a topic leads to such predictions.

Nature of hypothesis

Since the hypothesis is a clear statement of what is intended to be investigated, it should be

specified before launching of the planned research. This allows identifying the research objectives, the key abstract concept involved in the research and its relationship to both the stated problem and the literature review.

A hypothesis needs to fulfill some basic qualities. Accordingly, a hypothesis:

- should be testable –verifiable or falsifiable
- is neither moral nor ethical question
- neither too specific nor to general
- is a prediction of consequences
- should be considered valuable even if proven false

Purpose and importance of hypothesis in a scientific research

A research hypothesis has the following importance in research project;

- It provides a tentative explanation of phenomena and facilitates the extension of knowledge in an area
- It provides the investigator with a relational statement that is directly testable in a research study.
- It provide direction to the research
- It provides a frame work for reporting conclusions of the study
- It could be considered as the working instrument of theory, hypothesis can be deduced from the theory and from other hypothesis
- It could be tested and predictable

2.1.5 **Types of hypothesis**

Activity 12

Dear learner, have you heard about null and alternative hypotheses? If yes, what are null and alternative hypothesis? Attempt the question on separate sheet and try to compare your response to the definitions given below.

There are two types of hypothesis: the null hypothesis and alternative hypothesis.

Null hypothesis (H0)

The **null hypothesis** represents a theory that has been put forward, either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved. It has serious outcome if incorrect decision is made.

Alternative hypothesis (H1**)**

The **alternative hypothesis** is a statement of what a hypothesis test is set up to establish. It is opposite of Null Hypothesis, and accepted only if H0 is rejected.

Frequently "alternative" is the actual desired conclusion of the researcher.

Dear learner, look at the following practical examples concerning the development of hypothesis: If the research problem targets the analysis of '*Effect of Urea on water body'*, the **null hypothesis** could be that 'Urea has no effect on water body', or 'Urea has minimal effect than animal manure'. It is possible to write it formally as:

H0: there is no difference between Urea and animal manure.

The a**lternative hypothesis** might be that: The Urea has a different effect, on average,

compared to animal manure. It could also be written as:

H1: the two fertilizers have different effects, on average.

The animal manure has less effect, on average, than Urea on water body'. It is also possible to write the same alternative hypothesis as follows:

H1: Urea has great effect on water body**,** on average.

In most cases, special consideration is given to null hypothesis. This is mainly due to the fact that:

- the null hypothesis relates to the statement being tested, where as the alternative hypothesis relates to the statement to be accepted if / when the null is rejected,
- The final conclusion, once the test has been carried out, is always given in terms of the null hypothesis. We either 'reject H0 in favor of H1' or 'do not reject H0'; we never conclude 'reject H1', or even 'accept H1'.
- If we conclude 'do not reject H0', this does not necessarily mean that the null hypothesis is true, it only suggests that there is not sufficient evidence against H0 in favor of H1; rejecting the null hypothesis then, suggests that the alternative hypothesis may be true.

2. 1.6 **Use of academic library**

The organization of literature in the literature review section of a proposal, writing a review paper, and/or discussing the result of a given research work requires access to literature sources. A literature search can be done in various ways:

- Consultation of electronic systems such as internet searches, Cochrane data base of systematic reviews, etc.
- Contacting regional and national centers for information
- Discussion with other researchers
- Manual reference through library copies of specialist journals etc.

Using print information resources

The widespread availability of electronic versions of scholarly information resources is a relatively recent phenomenon. Until the early 1990s, researchers had to rely mostly on print-based journals, books, reference works, etc. At present, many libraries are adapting their policies to focus more on electronic access to such sources. Print-based information resources are in general regarded as less important than electronic resources.

Of the array of print resources on offer, books are perceived to be the most useful: most researchers have the opinion that book in print to be "very useful". Current and back issues of journals in print form are also found to be useful by many researchers.

Digital information

E-journals are increasingly important to the research process and the majority of professional researchers have embraced digital content. Currently, immediate access to information from once own desktop computer is almost taken for granted and gaining access to the full text journal article is becoming an issue than discovering the information sources.

There is evidence that once digital resources have been found, they are then used to 'power browse' for information. Power browsing is when a student or researcher selects just a few pages from an e-book or an e-journal to pick out the relevant information.

Information seekers prefer speedy access to a section of information and tend to spend very little time using content.

Information seekers do not completely rely upon search engines but will also use their own personal networks to find the information they need. These networks vary: academics are more likely to turn to co-workers, colleagues and other professionals, whereas students will turn to other students, classmates, family or friends for information.

In contrast to academic library users, younger non-academic users tend to be much less

competent in searching and evaluating results than they think, and use libraries and all types of electronic resources much less.

Activity 13

What do digital information seekers want from academic libraries?

How academic libraries can meet the needs of their users?

Though disciplinary differences exist, speed and convenience are always important to library users, who appreciate how useful electronic access to resources is compared to going to a physical library. Information seekers want access to more digital content of all kinds and formats.

Information seekers are beginning to require enhanced functionality in library systems. The entire process of information seeking needs to be supported by information systems, including increased access to resources such as full-text journal articles. Information seekers also want access to more enhanced content such as subject information, summaries, abstracts and tables of contents to assist them in evaluating resources.

Users' perceptions of library services have been slow to change and many people still tend to think of libraries as collections of books rather than providers of electronic resources. Academic libraries serve many constituencies with different needs and behaviors, such as academic discipline, research experience, demographic category and information-seeking context. Libraries need to understand those needs and adapt to meet them in a flexible manner:

- Library systems must do better at providing seamless access to resources such as full-text, e-journals, online foreign-language materials, e-books, a variety of electronic publishers' platforms and virtual reference desk services.
- Library catalogues need to include more direct links to resources and more

online content.

- Libraries should provide more digital resources of all kinds, from e-journals to curated data sets, as well as emerging services such as virtual research environments (VREs), open source materials, non-text-based and multimedia objects, and blogs.
- Library systems must be prepared for changing user behaviors, which include advanced search options, demands for immediate access and quick perusal of resources.
- Library systems need to look and function more like search engines (e.g. Google) and popular web services (e. g Amazon.com), as these are familiar to users who are comfortable and confident in using them.
- High quality metadata is becoming more important for discovery of appropriate resources.
- Librarians must now consider the implications of power browsing behaviors.
- Students need more guidance and clarity on how to find content and how to assess its worth as well as its relevance.
- The library must advertise its brand and its resources better to academics, researchers and students, demonstrating its value clearly and unambiguously.

Unit 3 Processes in research proposal development

Unit objectives

The objective of this unit is to determine the various steps involved in the development of research proposal. After completing this unit you should be able to:

- Know the contents of a research proposal
- Identify a research problem and formulate a research question/ hypothesis
- Set the objectives/ aims
- Develop a research design and methods
- Prepare a review of the literature related to the topic
- Cite references
- Prepare work plan
- Identify resources required and prepare a budget
- Produce complete research proposal

3.1 What is a research proposal?

After proper and complete planning of a research, the plan should be written down. The research proposal is the detailed plan of study. The term research proposal indicates that a specific course of action will be followed. It is a document which sets out your ideas in an easily accessible way. The intent of the written research proposal is to present a focused and scholarly presentation of a research problem and plan. The objective in writing a proposal is to describe what you will do, why it should be done, how you will do it, and what you expect will result. Being clear about these things from the beginning will help you complete your research in a timely fashion. A vague, weak or fuzzy proposal can lead to a long, painful, and often unsuccessful research writing exercise. A clean well thought-out, proposal forms the backbone for the research itself. A good research proposal hinges on a good idea. Getting a good idea hinges on familiarity with the topic. This assumes a longer preparatory period of reading, observation, discussion,

and incubation. Read everything that you can in your area of interest. Figure out what are the important and missing parts of our understanding. Figure out how to build/discover those pieces. Live and breathe the topic. Talk about it with everyone who is interested. Then just write the important parts as the proposal.

The written proposal:

- is a necessary guide if a team is working on the research;
- forces the students to clarify their thoughts and to think about all aspects of the study;
- is essential if the study involves human subject or experimental animals, in order to get the institution's ethical approval;
- is an essential component submitted for funding.

From the process of development of the research proposal, students benefit from the advice of supervisor (s), experts and colleagues in referring to their plan. But once a proposal for a study has been developed and approved, and the study has started and progressed, it should be adhered to strictly and should not be changed. Violation of the proposal can discredit the whole study.

A well thought out and well written proposal can be judged according to three main criteria.

- Is it adequate to answer the research question(s), and achieve the study objectives?
- Is it feasible in the particular set-up of the study?
- Does it provide enough detail that can allow another investigator to do the study and arrive at comparable result?

Issues to remember: Know your area of expertise: What are your strengths and what are your weaknesses? Play to your strengths, not your weaknesses.

Activity 14

Why you need to write a good research proposal?

Who do you think will want to read your research proposal?

3.2 **Components of research proposal**

The basic components of a proposal are described in this section in the order in which they most logically appear in a proposal.

Components of research proposal:

1. Title page
2. Summary/Abstract
3. Introduction/background
4. Statement of the problem
5. Literature review
6. Hypotheses/questions
7. Conceptual framework
8. Objective/aim of the study
9. Research methods, material and procedure
    - Study area
    - Study design
    - Study subject
    - Eligibility criteria (If any)
    - Sample size
    - Sampling methods
    - Method of data collection
    - Description of variables
    - Data quality assurance

- Operational definitions
- Plan of data analysis

10. Work plan
11. Budget
12. References
13. Appendices/annexes

3.2.1 **Title page**

A title ought to be well studied, and to give, so far as its limit permits. A definite and concise indication of what is to come. The title of your research proposal should state your topic exactly in the smallest possible number of words. Put your name Department/faculty/college, the name of your advisor (s), and date of delivery under the title.

All words in the title should be chosen with great care, and association with one another must be carefully managed. The title page identifies the proposal and provides the endorsement of appropriate body (advisor). A good title is defined as the fewest possible words that adequately describe the contents of the study. Title is a label: it is not a sentence. Titles should almost do not contain abbreviations. The title page has no page number and it is not counted in any page numbering.

Activity 15

What do you think of the following research topic? Discuss on their merits and provide your own alternative title on your not book.

How does the human brain works when faced with stress?

The workings of the human brain in times of stress

Stress and the human brain

Effect of stress on short –term memory

Abebe's memory function during semester final exams

3.2.2 **Summary/Abstract**

The abstract is one page brief summary of proposal. It needs to show a reasonably informed reader why a particular topic is important to address and how you will do it. To that end it needs to show how your work fits into what is already known about the topic and what new contribution your work will make. Specify the question that your research will answer, establish why it is a significant question; show how you are going to answer the question. Do not put information in the abstract that is not in the main text of your research proposal. Do not put references, figures, or tables in the abstract.

Issues to remember: The abstract is a concise summary of the material presented in the proposal. Though it appears at the front of the proposal, it is written last. A well prepared summary enables the reader to

- Identify the basic concepts of the document quickly and accurately
- Determine its relevance to their interests, and
- Decide whether they need to read the document in its entirely

Activity 16

Do you think it would be appropriate to include your method in the abstract?

Summarizing a wide topic is difficult than it sounds. By way of illustration, make single sentence statements on the following topics:

The role of water in living organisms

Environmental impact of plastic wastes

Effect soil on the potassium content of a plant

3.2.3 **Introduction/Background**

The introduction is the part of the proposal that provides readers with the background information for the research proposal. Its purpose is to establish a framework for the research, so that the readers can understand how it is related to other research.

The introduction should address the following points:

- Sufficient background information to allow the reader to understand the context and significance of the questions you are trying to answer
- Proper acknowledgement of the previous work on which you are building.
- Sufficient references such that a reader could, by going to the library, achieve a sophisticated understanding of the context and significance of the question.
- The introduction should be focused on the research question (s).
- All cited work should be directly relevant to the goals of the research.
- Explain the scope of your work, what will and will not be included.
- A verbal road map or verbal table of contents guiding the reader to what lies ahead.
- It is obvious where introductory material ("old stuff") ends and your planned contribution ("new stuff") begins.

Activity 17

Is it appropriate to include in the introduction theories, hypothesis and findings that go against your stated hypothesis?

Is it appropriate to include research works in progress that offer an alternative hypothesis?

3.2.4 **Statement of the problem**

Most research proposals may be considered as responses to a problem. The prospective researcher should think on what caused the need to do the research (problem identification). The question that he/she asks him/herself is:

> Are there questions about this problem to which answers have not been found up to the present?

The research problem should be stated in such a way that it should lead to analytical thinking on the part of the researcher with the aim of possibly concluding solutions to the stated problem. The problem statement describes the context for the study and it also identifies the general analysis approach. Effective problem statements answer the question "***why does this research need to be conducted."***

3.2.5 **Literature review**

To conduct research regarding a topic, by implication, means that the researcher has obtained sound knowledge with regards to the research topic. Literature review is not a compilation of every work written about a topic. It is not a list of sources reviewed separately for their own merit. A literature review is a description of the literature relevant to a particular field or topic. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypothesis, what questions are being asked and what methods and methodologies are appropriate and useful. As such, it is not itself a primary research, but rather it reports on other findings.

How to organize a literature review

There are a number of ways of organizing a literature review. Here is on suggestion:

A. **Introduction:** define the topic, together with your reason for selecting the topic. You could also point out overall trends, gaps, particular themes that emerge, etc.
B. **Body:** this is where you discuss your sources. Here are some ways in which you could organize your discussion:

- **chronologically:** for example if writers views have tend to change over time. There is little point in doing the review by orger of publication unless shows a clear trend;
- **thematically:** take particular themes in the literature;
- **methodologically:** here, the focus is on the methods of the researcher, for example, qualitative versus quantitative approaches.

C. Conclusion: summarize the major contributions evaluating the current position, and pointing out flaws in methodology, gaps in the research, contradictions, and areas of further study.

Activity 18

Is Wikipedia an authoritative scholarly source of information?

You are studying the impact of flooding on the loss of livestock in a region of Ethiopia. Would the Ethiopian Herald newspaper be a reliable source of information for such study?

3.2.6 **Questions and/or hypothesis**

A research question poses a relationship between two or more variables but phrases the relationship as a question; a hypothesis represents a declarative statement of the relationship between two or more variables. Deciding whether to use question or hypothesis depends on factors such as the purpose of the study, the nature of the design and methodology of the research. Make a clear and careful distinction between the dependent and independent variables and be certain they are clear to the reader.

3.2.7 **Conceptual Framework**

Conceptual framework is in part conceptual, in part valuational, and in part practical (or operational), and all of these factors must typically be considered.

3.2.8 **Objectives/aim of the study**

The objectives of a research delineate the ends or aim which the inquirer seeks to bring about as a result of completing the research undertaken. An objective may be thought of as either a solution to a problem or a step along the way toward achieving a solution: an end state to be achieved in relation to the problem. Objective should be closely related to the statement of the problem.

Objectives should be:

- Simple (not complex)
- Specific (not vague)
- Stated in advance (not after the research is done), and
- Stated using action verbs that are specific enough to measured.

Commonly, research objectives are classified into **general and specific objectives.**

- General objective
    - What exactly will be studied?
    - General statements specifying the desired outcome of the proposed project
- Specific objectives
    - Specific statements summarizing the proposed activities and including description of the outcomes and their assessment in measurable terms
    - It identifies in a greater detail the specific aims of the research project, often breaking down what is to be accomplished into smaller logical components
    - Specific objectives should systematically address the various aspects of the problem as defined under ’Statement of the Problem’ and the key factors that are assumed to influence or cause the problem. They should specify what you will do in your study, where and for what purpose

<u>Why should research objectives be developed?</u>

The formulation of the objective will help you to:

- **Focus** the study (narrow down to essential)
- **Avoid** the collection of data which are not strictly necessary for understanding and solving the problem you have identified; and
- **Organize** the study into clearly defined parts or phases.

Properly formulated objectives will facilitate the development of your research methodology and will help to orient the collection, analysis, interpretation, and utilization of data.

Issues to remember: keep in mind that when a proposal is evaluated the anticipated results will be compared to the objectives. If the objectives have not been spelled out clearly, the proposal cannot be evaluated.

Take care that the objectives of your study:

Cover the different aspects of the problem and its contributing factors in a coherent way and in a logical sequence;

Are clearly phrased in operational terms, specifying exactly what you are going to do, where, and for what purpose;

Are feasible;

Are realistic considering local conditions;

Are phrased to clearly meet the purpose of the study; and

Use action verbs that are specific enough to be evaluated.

3.2.9 **Methods, materials and procedures**

The methods or procedures section are really the heart of the research proposal. Indicate the methodological steps you will take to answer every question, to test every hypothesis illustrated in the question/hypothesis section or address the objectives you set.

What belongs to the methods section of a research proposal?

- Information to allow the reader to assess the believability of your approach
- Information need by another researcher to replicate your experiment
- Description of your materials, procedure, theory
- Calculations techniques, procedure, equipment, and calibration plots
- Limitations assumptions, and range of validity
- Description of your analytical methods, including reference to any specialized statistical software.

The proposal should describe in detail the general research plan. (may not necessarily be true for all types of research)

- Description of the study area
- Description of the study design
- Description of the study participants
- Eligibility criteria (if any)
- Determination of sample size (if any)
- Description of sampling process (sampling method)
- Method of data collection
- Description of the expected outcomes and explanatory variables… (if any)
- How data quality is ensured
- Operational definition
- Presentation of the data analysis methods

3.2.9.1 **Variables and indicators**

A variable is a characteristic of the study subjects (e.g., nutritional status), and an indicator is a measurement collected during research that is assumed to reflect the variable (e.g. body weight).

The **variable-indicator-method matrix** (VIM) is a systematic way to organize the

relationship between variables of interest and potential indicators of these variables. The VIM should: relate every variable (cause) of the causal model to at least one indicator; describe the methodology by which each indicator will be surveyed; cite the literature source of the methodology selected. The indicators should be selected according to the following criteria: Validity, feasibility or/ appropriateness, accuracy, and precision.

Validity - Does it measure (quantify or describe) what we assume it measures? For example, does the indicator we have chosen to show obesity indeed measure the fatness of a person?

Feasibility/appropriateness

- Is the cost realistic?
- Is the equipment available?
- Is the methodology appropriate, and can data be obtained?

Accuracy - getting the correct answer. This includes: sensitivity and specificity

Precision – it refers to reliability, reproducibility, and repeatability. There are several kinds of precision, including:

- Instrumental (precision of analytical instrument on same sample on different occasions);
- biological (precision of same subject on different occasions);
- intra - observer (precision of same tester on different occasions on same subject);
- Inter - observer (precision of different testers on the same subject at same occasion).

Types of variables

Variables are defined by their use in research. It could be independent, dependent, or constant. Independent and dependent variables are related to one another. Independent variable is a variable that is manipulated by the research in experimental research. Thus, the Independent variable is the variable that the experimenter can change while doing the experiment.

A dependent variable is, however, a variable measured by the researcher, and is expected to change as a result of the independent variable manipulation. Thus, the dependent

variable is one that changes when the independent variable changes. In other words, the dependent variable *depends* on the outcome of the independent variable.

For instance: if your experiment deals with measuring the growth rate of bacteria exposed to UV light for 20, 30, and 60 minutes, the exposure time is the independent variable (the variable that you can control). Change in number of bacteria (growth) is the dependent variable. The pattern of growth of bacteria through the exposure time depends on the length of exposure time. Constants are variables that are not allowed to vary.

Activity 19

Select two or more research titles and identify the possible dependent and independent variables for each of the research title.

What is the advantage of identifying the dependent and independent variables, if any, of a research topic?

3.2.9.2 Study design

After variables to be surveyed have been identified and indicators related to each of the variables have been defined, the study design has to be selected and formulated. The research design is a processes that show how exactly the research is going to be performed. The purpose of this section is to identify and justify the research methods selected for the research. The choice of methods depends on the variables to be measured and the cause-effect relationships among them. Once the decision has been made to use these tools, the following questions should be considered before designing them:

- What exactly do you want to know, according to the objectives and variables identified earlier?
- Is questioning the right technique to obtain all answers, or do you need additional techniques, such as observations or analyses of records, laboratory

analysis?

- Did you understand the topic sufficiently to design appropriate technique of data collection and analysis?
- Are our informants mainly literate or illiterate? (If illiterate, the use of self-administered questionnaires is out of the question).
- How large should the samples that will be interviewed/ experimented?

The following are the common study designs:

- Descriptive study (observational study)
- Prospective study (prospective cohort study, or longitudinal study)-some variables are assayed at the start of a study, then after period of time the outcomes are determined.
- Retrospective study (case-control study), reporting data of one subject
- Cross-sectional study- in this type of study variables of interest in a sample of subjects are assayed once and the relationships between them are determined.
- Experimental study is intervention study because you do more than just observe the subject. It could be with or without a control group.

3.2.9.3 **Study Population**

The proposal needs to define the criteria to be used in selecting the population to be studied and needs to distinguish the selection criteria from the descriptive data that will be collected to characterize the sample. For example, the selection criteria for a given study might be *Plasmodium falciparium* malaria infected adult male cases. In this case all other people such as all women, all children, men infected with *P. vivax*) and malaria cases with different species of *Plasmodium* would be excluded. The study population can then be characterized by age, sex, species of *Plasmodium* parasite they infected with etc.

Ideally, the sample selected from a population is representative of the entire population, and therefore the characteristics of the study sample describe those of the entire population.

CHECKLIST to evaluate the appropriateness of the study population

1. Identify the population you have chosen on the following line: _____

2. Answer the following questions with respect to the *structure of the population*:

a. Is the population relatively homogeneous group of individuals or other units?

b. Could the population be considered to consist generally of equal "layers," each of which is fairly homogeneous in structure?

c. Could the population be considered to be composed of separate homogeneous? layers differing in size and number of units ____ ____ comprising them?

d. Could the population be envisioned as isolated islands or ____ ____ clusters of individual units, with the clusters being similar to ____ ____ one another in composition?

3. Through what means would you extract a representative sample from the total population? Describe your procedure on the following lines:-

_____

_____

4. Is your sampling procedure appropriate for the characteristics of the population?

Yes ____ No____

5. Have you guaranteed that your sample will be chosen by chance and yet will be representative of your population? Yes ____ No____

6. If the preceding answer is yes, explain how this has been done_____

_____

7. Indicate what means will be employed to obtain the information you need from the sample:

8. What are the weaknesses inherent in this method of obtaining the data?

9. What safeguards have you established to counteract any potential bias in your approach to data collection? Be specific.

3.2.9.4 **Sample size and sampling technique**

After identification of the variables and their indicators, the selection criteria for the population to be studied, the sample size and sampling methods must be defined. By convention, N represents the number of individuals in the population, and *n* the number of individuals in the sample. It is important that the sample size should be large enough that statistically significant differences will be identified if they exist. The calculations concerning sample size depend on: the primary question that the researchers want to investigate and the methodology he/she will use to answer the question. However, a biostatistician or statistical textbook should be consulted before the final sample size is selected.

The following are some sampling methods used in research:

Probability sampling methods – it is rely on formal random sampling techniques to identify the units to be included.

Simple random sampling- A fixed percentage of the population is selected using a formal random process, such as a random number generator or random number table.

Systematic random sampling- The 'n' sampling units are selected from the sampling frame at regular intervals (e.g., every tenth student). When systematic methods are used, the starting point in the first interval is selected on a formal random basis.

Stratified random sampling - In this case before selection, the sampling frame is divided into strata based on factors likely to influence the variable being estimated. Then a simple random or systematic random sample is used within each stratum.

Cluster sampling- Primary sampling units are defined, which are logical groups or clusters (e.g., classrooms) of secondary sampling units (e.g., individual children). The clusters can be selected by systematic, simple, or stratified random methods, and *all* individuals within the primary sampling units (or clusters) are selected to participate in the research.

Non-probability sampling methods- do not rely on formal random techniques to identify the units to be included.

Convenience sampling- The sample is selected because it is easy to obtain. Using convenience or judgment sampling often produces biased results, regardless of whether the researcher believes he/she can select representative samples. Therefore, these samples should rarely be used for survey purposes.

Purposeful sampling- The selection of units is based on known exposure or target population.

3.2.9.5 **Data collection tools**

Since the quality of research depends on the quality of the data collection tools, designing good research tools is an important and time-consuming phase in the development of most research proposals. There are multiple ways of data collection. The ideal situation would be to collect from more than one source and/or to collect more than one type of information. The selection of a method for collecting information must balance several concerns including: resources available, reliability, investigation and coverage of resources, and the skill of the investigator.

Examples of different data collection methods are given below;

- Interview (structured and unstructured)
- Observation
- Questionnaires (surveying with closed-ended questions)
- Experiments/clinical trials.

Interviews

Interview is a technique that is primarily used to gain an understanding of people on certain issues. Interviews can be undertaken on a personal one-to-one basis or in a group. They can be conducted at work, at home, in the street or in a shopping centre, or some other agreed location.

Face -to -face interviews

It has a distinct advantage of enabling the researcher to establish rapport with potential participants and therefore gain their cooperation. These interviews yield highest response rates in survey research. They also allow the researcher to clarify ambiguous answers and when appropriate, seek follow up information.

Telephone interviews

They are less time consuming and less expensive and the researcher has ready access to anyone who has telephone. Disadvantages are that the response rate is not as high as the face-to- face interview as but considerably higher than the mailed questionnaire.

Computer Assisted Personal Interviewing

It is a form of personal interview, but instead of completing a questionnaire, the interviewer brings a laptop or hand-held computer to enter the information directly into the database. This method saves time involved in processing the data, as well as saving the interviewer from carrying around hundreds of questionnaires. However, this type of data collection method can be expensive to set up and requires that interviewers have computer and typing skills.

Questionnaires

Questionnaires are a popular means of data collection, but are difficult to design and often require many rewrites before an acceptable questionnaire is produced. There are different types of questionnaires:

Paper-pencil-questionnaires

It can be sent to a large number of people and saves the researcher time and money. People are more honest while responding to the questionnaires due to the fact that their responses

are unidentified.

Web based questionnaires

It is a new and certainly growing methodology. It is the use of internet based research. This would mean receiving a questionnaire through an e-mail and then fill back. This type of research is often quicker and less detailed. Some disadvantages of this method include the exclusion of people who do not have a computer or are unable to access a computer. Also the validity of such surveys is in question as people might be in a hurry to complete it and so might not give accurate responses.

Focus groups discussion

A focus group discussion is a kind of interview conducted by a trained moderator in a non-structured and natural manner with a small group of respondents. The moderator leads the discussion. The main purpose of focus groups is to gain insights by listening to a group of people from the appropriate target groups talk about specific issues of interest.

Observation

Observation is recording of the behavioral patterns of people, objects and events in a systematic manner. Data generated through observation are considered as strong in validity because the researcher is able to collect a depth of information about a particular behavior.

Case-studies

The term case-study usually refers to a fairly intensive examination of a single unit such as a person, a small group of people/animal or plant. Case-studies involve measuring what is there and how it got there. It can enable the researcher to explore, unravel and understand problems, issues and relationships. It cannot, however, allow the researcher to generalize, that is, to argue that from one case-study the results, findings or theory developed apply to other similar case-studies. The case looked at may be unique and, therefore not representative

of other instances. It is, of course, possible to look at several case-studies to represent certain features of management that we are interested in studying.

Activity 20

What are the advantages and disadvantages of different data collection tools such as interview, questionnaire, observation, focus group discussion and case-study?

3.2.9.6 **Data Analysis and interpretation**

After completing this session you should be able to:

- Differentiate or analysis methods that fits different types of data (qualitative and quantitative)
- Describe how data can be best be analyzed and interpreted based on the objectives and variables of the study.
- Prepare a plan for the processing and analysis of data for the research proposal you are developing.
- Define on the type of data analysis and level of significance test for different outcomes.

Since data cannot speak by themselves without analysis and interpretation in line with the objective set, knowledge of different data analysis tests are very important. In this section it was attempted to incorporate the simplest data analysis.

Statistical analysis

Data collected with different tools should be analyzed properly using different statistical knowledge. Data don't speak for themselves. They show what the analyst can detect. As with most other aspects of a study, analysis and interpretation of the study should be related to the study objectives and research questions. When proposal is developed the researcher

should know that what kind of data will be generated and how it will be analyzed. So that, the statistical package to be used in the analysis including the computer software must be specified. The purpose of this statistical analysis is to allow the researcher to draw conclusions from the data obtained. Therefore, all aspects of the research proposal should be formulated so that valid statistical conclusions can be drawn.

Appropriate statistical methods should be selected from the available statistical packages based on the study design and the sampling techniques. Before analyzing the data with a certain statistical test, it is essential to determine some characteristics of the data.

Research data could be qualitative or quantitative in its nature. Sorting them into their respective category is the primary work in data analysis. For instance qualitative data are data collected from interview with open-ended questions, focus group discussions, observations and others. The first basic step in the analysis of qualitative data, are hence answers to open questions, is listing, ordering in relation to the objective of the study and coding. Then based on categories of the data, interpretation and summarization can be done.

The usual analysis approach is to begin with **descriptive analysis**, to explore and gain a feel for the data. Exploration of the data at some point becomes descriptive analysis, to examine and then to report measures of frequency (incidence, prevalence), extent (means,
survival time), association (differences, ratios), and impact (association, effect). These measures will be computed for sampled population and probably for the entire study population.

Quantitative data are expressed in numbers and they are usually presented in figures and frequency tables. After frequency distribution and different types of cross tabulations are made, the type of statistical analysis required has to be selected in order to determine the differences and associations found are significant or just due to chance. In this case the level of significance to be set for primary outcomes (the main result of the study) is usually P = 0.05 (this means 5 of the 100 outcomes are due to chance and 95 of them are the real outcomes). Whereas, for secondary outcomes (supportive results) the level of significance should be considered at P = 0.01 (it means that, out 100 outcomes 1 could be due to chance).

The most common significance tests are:

- Student's-test and chi-square test to determine differences between groups, if observations are unpaired.
- The paired t-test and chi-square (McNamara's X^2) test is used to determine differences between groups, for paired observations.
- For measuring associations between variables, the odds ratio, regression and correlation can be used.

3.2.9.7 **Ethical considerations**

Each study and survey conducted on human beings and animals needs approval from an official committee of a research institution (or elsewhere). This committee is responsible to evaluate the research proposal according to the following criteria: maximizing benefit, avoiding harm and minimizing discomfort, confidentiality and conflict of interests. For researches that involve human subject and animals, the guidelines of most review committee are highly recommended as a source of detailed information for ethical considerations. It is the function of the ethical committee to monitor and control the implementation of ethical standards of the researcher.

3.2.10 **Work plan**

Work plan is a schedule, chart or graph that summarizes the different components of a research proposal and how they will be implemented in a coherent way within a specific time-span.

It may include:

- The task to be performed;
- When and where the task will be performed;
- Who will perform the task and the time each person will spend on them;
- It describes the plan of assessing the ongoing process toward achieving the research objectives;
- The plan specifies how each project activity is to be measured in terms of

completion, the time line for its completion;

- A good work time plan enables both the investigators and the advisors to monitor project progress and provide timely feedback for research modification or adjustments.

Issues to remember: In the work plan:

- Different components/phases/stages of the study should be stated
- Description of activities in each phase
- Time required to accomplish the various aspects of the study should also be indicated

The GANTT chart

A GANTT chart is a planning tool that depicts graphically the order in which various tasks must be completed and the duration of each activity.

The GANTT chart indicates the task to be performed; who is responsible for each task; the time each task is expected to take. The length of each task is shown by a bar that extends over the number of days, weeks or months the task is expected to take.

3.2.11 **Budget and funding**

Most often than not, you will require to secure funds from a funding organization to cover the cost of conducting a research project. The items to consider when drawing up a budget requirement are outlined below. In addition, it is important to remember that the funding agency will invariably also read through the whole proposal (not just the budget requirement). Therefore, it is critical that the entire proposal document is well thought out written to effectively communicate the aim of the research and how you plan to achieve it.

Budget items need to be explicitly stated

- Cost for every budget items should be quantitatively shown
- There might be a need for budget justification of certain costs whose requirement is not obvious

Typically, a proposal budget reflects direct and indirect costs.

Direct costs

- **Personnel:** Salaries and wages of all participants of the study Principal investigator, supervisor, data collector, drivers, guards, data entry clercks, data analysis, report writing, etc
- **Consumable supplies:** Office supplies (stationeries), computers, chemicals, and educational materials
- **Equipments:** properties which are expensive
- **Travel:** Cost of project-related travel
- **Communications:** postage, telephone, telegram, fax, e-mail charges associated with a project
- **Publication:** the cost incurred of preparing and publishing the results of the research. It includes: technical reports, manuscripts, illustrations, graphics, photography, slides, and overheads
- **Other direct costs:** costs of all items that do not fit into any of the above direct costs

Indirect costs:

Those costs incurred in support and management of the proposed activities that cannot be readily determined by direct measurement. Examples include;

- Overhead costs for institutions or associations
- General administrative costs
- Operational and maintenance
- Depreciation and use allowance

Budget justification

It is not sufficient to present a budget without explanation. The budget justification follows the budget as an explanatory note justifying briefly, in the context of the proposal, why the various items in the budget are required. Make sure you give clear explanations concerning why items

that may seem questionable or that are particularly costly are needed and discuss how complicated expenses are calculated.

Obtaining funding for research projects

Funding for research project may be available from local, national or international agencies. Besides preparing a good research proposal the researcher should able to increase the chance of securing adequate funds from the funding agencies. The following are useful strategies for researchers to obtain adequate funds:

A. Familiarize yourself with the policies of agencies. Such polices and priories may be:
    → Implicit, i.e. known to officials in the agency and to other local researchers who have previously been funded by that agency. Obtain the names of such person and make direct contact with them.
    → Explicit, i.e. available from policy documents issued by the agency. The funding policies of the agencies may emphasize:
        - a priority given to research aimed at strengthening a particular program
        - institutional building, i.e. building the capacity of the institution to do research
        - targeted to a specific thematic area of research (for example, health, nutrition, etc)
B. Identify the procedures, deadlines and formats that are relevant to each agency.
C. Obtain written approval and support from relevant local and national authorities and submit together with your proposal.
D. For a beginner researcher like you, associate yourself with an established researcher/advisor. Host agencies scrutinize the credibility of the researcher to whom funds are allocated. Such credibility is based on previous projects that were successfully completed.
E. Build up your own list of successfully completed projects (i.e your own reports, publications, etc.)

3.2.12 **References**

You must give references to all the information that you obtain from books, papers in journals, and other sources. References may be made in the main texts using different styles and also placed as list at the end of the research proposal. The exact format for depicting references within the body of the text as well as the end of the proposal varies from one disciple to another. It is best that you consult someone who is familiar with the format in your particular area of research.

For a journal paper give:

- the name of the authors,
- the year of publication,
- the title of the paper,
- the title of the journal,
- the volume number of the journal,
- the first and the last page numbers of the paper.

For a book give:

- the author,
- the year of publication,
- the title, and the edition number if there is one,
- the name of the publishers,
- the page numbers for your reference.

For an internet references give:

- the author of the web page,
- the title of the item on the web page,
- the date the item was posted on the web page,
- the date the item was assessed from the web page,
- the complete and exact URL.

Particularly with references obtained from websites, it is important to establish the reputability and reliability of the website you are making reference to.

Every reference in your main text must appear in the list at the end of your proposal, and every reference in the list must be mentioned in your main text.

3.2.13 **Appendices/annexes**

In the appendices of your proposal include, questionnaire and other collection forms, dummy tables, biographical data on the principal investigator, and the consent form (if any)

Unit end exercise (Assignment)

1. Identify your own research topic.
2. Write the introduction section of the topic you identified.
3. Write the statement of the problem for your topic.
4. Review literature for identified topic.
5. Formulate your own research question and hypothesis (relevant to your topic)
6. Define clearly your general and specific objectives.
7. Write clearly the research design/methods for the identified topic.
8. Develop your work plan.
9. Prepare estimated budget of your research.
10. Choose one method of citing references and write all the references you used.

Unit 4: Presentation of Scientific findings

> *"A scientific paper is an organized description of hypotheses, data and conclusions intended to instruct the reader. Papers are a central part of research. If your research does not generate papers, it might just as well not have been done. 'Interesting and unpublished' is equivalent to 'non-existent' ".*
>
> By George M. Whitesides, 2004

Section objectives

At the end of this section, you will be able to:

- use the types of knowledge and information management needed for scientific paper writing
- identify main components of a scientific paper
- Describe the classic AIMRAD structure for a report.
- Describe the contents to be reflected in the introduction, materials and methods, results and discussion section of a scientific report.
- know how to cite and list references in a research report by examining recent papers in any well established scientific journal without plagiarism
- familiarize with details of organization, section headings, methods of data presentation
- write a clear, well-structured academic texts of some length in an appropriate style (articles, dissertations, etc.)
- identify necessary conditions for oral presentation
- prepare and present scientific poster

Introduction

What is a scientific paper?

A scientific paper is a written and published report describing original research results. A research report deals with results of completed research work. After completing a research work, it is generally produced in the written 'form' and is called research report or thesis. A detailed description of research activities are provided in it. It has a variety of formats and varies as to its length. It is written in past tense and in third person. It is the final form of the research work.

Generally, research report serves the purpose of communicating the results of a research work done.

Activity 21

Discuss about some benefits of a research report and compare your answers with the short description given below.

Need of Research Report

Writing a research report is very challenging task for the researcher. A good research report requires sufficient-experience and insight about his/her research activities. A research report is needed due to the following reasons:

- The research must be reported in full and its results should be subjected to a criticism and verification.
- The research work is done for the benefit of human being; therefore, it must be communicable to the general public for the practical use.
- The research should be considered to be the culminating act for reflective thinking. It encourages other persons to take up some problem for further investigation.
- The research report requires the creative thinking of a researcher to review the related studies and discussing the result of the study and also suggest some new problems for further studies.
- The research report is also necessary for giving shape and form to the investigation and solidifying it.
- It is needed for providing a clear picture of research method, sample and techniques used in conducting the research work.
- The research report is meant for popularizing the new contributions in the discipline.

How can I write a scientific report?

The best way to write a scientific paper is by asking yourself: *What does the reader need to be able to assess my material most readily? How can I best tell this story for the reader?*

But Don't ask yourself: *How do I want to present this material?* This is quite different; it is looking at it from your point of view, not the reader's. Documents that are written from the writer's point of view run the risk of being difficult for a reader to readily understand.

4.1 **Writing a scientific report**

Introduction

Dear learner, scientific written communication includes various types of reports, theses or dissertations, journal articles, slide presentations, posters, books and book chapters, technical manuals/users guides and research or grant proposals. Writing reports in science is becoming increasingly important. Scientists write articles to describe their findings to the community in a transparent manner. Within a scientific article, scientists present their research questions, the methods by which the question was approached and the results they achieved using those methods. In addition, they present their analysis of the data and describe some of the interpretations and implications of their work.

Learning how to Write Like a Chemist

Many effective writers develop their discipline-specific writing skills by reading and analyzing the works of others in their fields. Learning to write in chemistry is no exception; chemistry specific writing skills are developed by reading and analyzing the writing of chemists. This approach can be coined by the phrase “read-analyze-write”.

At the core of the read-analyze-write approach is a systematic way to read and analyze writing (genre analysis). The analysis focuses on five such components: audience and purpose, organization, writing conventions, grammar and mechanics, and science content. Each component can be further divided into two or more subcomponents.

Audience and Purpose

Before you begin to write, you must decide the audience that is most likely to read your work and the reason or purpose for writing it in the first place. In turn, the audience and purpose will influence the levels of detail, formality, and conciseness that you use in your writing and the words that you choose.

Chemists write for many different audiences, including students, teachers, and Ph.D. chemists, to name only a few. Thus, it is instructive to divide audience into different categories. For our purposes, let us consider four categories:

- the expert audience,
- the scientific audience
- the student audience, and
- the general audience.

The expert audience: includes professional chemists with advanced knowledge in a sub-discipline of chemistry, such as biochemistry, analytical chemistry, or organic chemistry. The sub-discipline is often reflected in the name of the journal written for experts in that field (e.g., *Biochemistry*, *Analytical Chemistry*, or *The Journal of Organic Chemistry*).

The scientific audience: comprises readers with scientific backgrounds but not necessarily in the authors' field or sub-discipline. For example, a biologist or geologist asked to review a chemist's research proposal would be considered as a scientific audience.

The student audience: consists of individuals who are reading to learn chemistry at any level, such as a high school student reading an introductory chemistry book or a graduate student studying a book on quantum mechanics.

The general audience: includes readers who are interested in a chemistry topic but with little to no formal training in chemistry, such as an English or history teacher reading *Science News* or *Popular Science.*

Together, these four audiences form a continuum that spans a wide range of expertise in chemistry (figure 4.1)

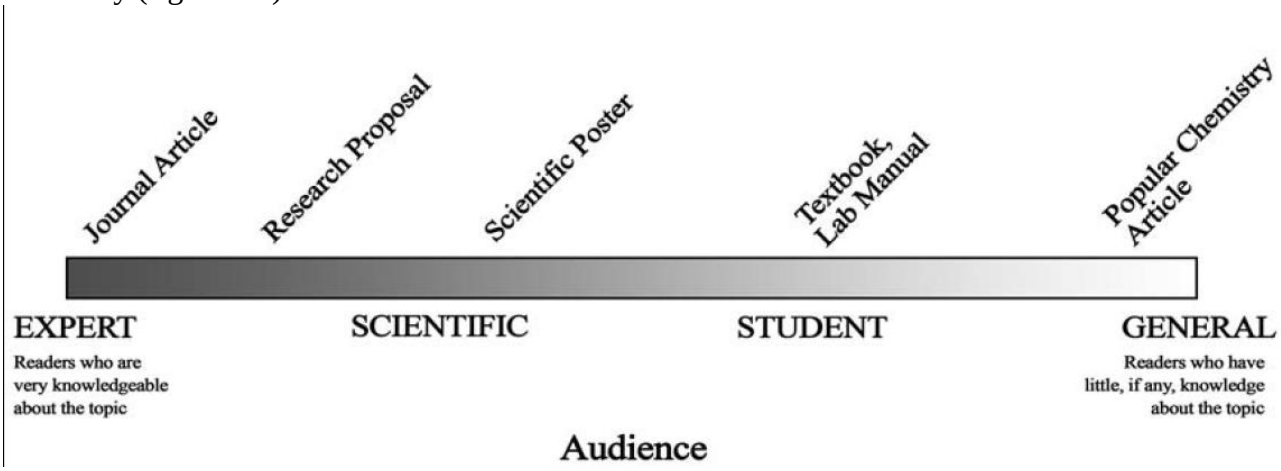


Figure 4.1: Wide range of Audience based on expertise in Chemistry

Activity 22

Match the written materials listed in Column "A" to the corresponding correct audience listed under column "B"

"A"	"B"
Journal Article	Student audience
Research Proposal	Expert audience
Text Book	Scientific audience
Popular science news letter	General audience
Scientific poster	

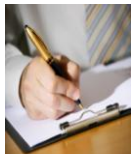
In general, journal articles are written for an expert audience, research proposals and scientific posters for a scientific audience, textbooks for a student audience and popular science articles for a general audience. Of course, these pairings are only guidelines. A genre can change position on the continuum if an audience is expected to have more (or less) chemistry-specific knowledge. For example, a poster presented at a highly technical conference should address an expert audience, but a poster presented at an undergraduate research conference should target a student or general audience. Moreover, a single genre often addresses more than one audience. Although a journal article is written primarily for an expert audience, parts of its Introduction section are often written for a scientific audience. You can see that determining your audience is an integral part of the writing process.

Closely linked to audience is **purpose**; a genre is also influenced by the purpose for the writing. Several different purposes for chemistry-specific writing can be listed as follows:

Purpose	**What to write?**
To present research results or convey new scientific insights	journal articles and posters
To request funding	research proposals
To teach or instruct	textbooks
To convey instructions	lab or operating manuals

To provide chemical information	safety data sheets
To communicate with colleagues	memos or e-mails

Conciseness of a scientific report



I find that there is nothing more tedious than papers that go on and on, with no obvious point.

Richard Malkin, University of California–Berkeley

Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts.

—William Strunk, Jr., *Elements of Style*

Wordiness

Activity 23

The American Chemical Society (ACS) guideline **(Annex 1)** for writing manuscripts to be submitted to ACS journals in short ACS Style Guide recommends that the following phrases be omitted from papers

- As already stated
- It has been found that
- It has long been known that
- It is interesting to note that
- It is worth mentioning at this point
- It may be said that
- It was demonstrated that

Discuss why ACS recommends these words be omitted? What words can substitute these phrases listed above?

ACS style guide recommended omission of the phrases because they are vacuous and contribute to wordiness.

The ability to write concisely is a desirable skill among chemists and an important step toward sounding like an expert. The key is to say only what needs to be said, deleting unnecessary words (i.e., words that add little substance, state the obvious, or can be inferred by other words in the sentence).

Activity 24

Compare the following two sentences.

Sentence 1: In a paper published by Bonderic et al.,[2] experiments were described that led to similar results.

Sentence 2: Bonderic et al.[2] reported similar results.

Which one of the two sentences is written concisely?

It is clear to the reader that Bonderic et al. published a paper because of the in-line citation. It is also obvious that "experiments were described" in that paper. The wordy sentence contains so many unnecessary words that the authors' message is nearly lost. Therefore, Sentence 2 is concise and delivers the message correctly.

Sound like an expert

Learning to write concisely will help you sound like an expert. This skill requires that you delete words, as you revise and edit your work that add little substance or state the obvious.

Activity 25

Read the following wordy passage (adapted from Liu et al., 2001) and identify five words and/or phrases that could be deleted to make the passage more concise:

After the mixture had been dried, the remaining residue (CD-capped gold nanoparticles + compound 5) was found to express insolubility in dry $CHCl_3$ but the solubility was restored when water was used in the equilibration of the chloroform. In our judgment, this finding clearly

makes it apparent that there must be some water necessary for the efficient phase transfer of the nanoparticles into $CHCl_3$. This finding leads to the conclusion that the idealized structure that has been proposed for the nanoparticles after they have been transferred to the chloroform phase (Scheme 2) has some aspects that must be similar to the structure of reverse micelles. We come to the conclusion that these nanoparticle-centered assemblies are similar in a conceptual way to gold-filled reverse micelles. (124 words)

How to make paragraphs in a report more concise?

There are several ways to make the paragraph more concise. One technique is to **replace a group of words with a single word that has the same meaning.** For example:

Wordy	This finding *makes it apparent* that . . .	(6 words)
More concise	This finding *demonstrates* that . . .	(4 words)
Wordy	We *come to the conclusion* that . . .	(6 words)
More Concise	We *conclude* that . . .	(3 words)

Removing Unnecessary Words

The ACS Style Guide provides many useful tips for converting wordy multiple word phrases into more concise alternatives. The following Table can be used as an example:

Table 4.1 Suggestions for concise writing (adapted from *The ACS Style Guide)*

Wordy Phrase	**Concise Alternative**
a number of	many, several
based on the fact that	because
by means of	by
despite the fact that	although
due to the fact that	because
if it is assumed that	if
in order to	to
in spite of the fact that	although
is/are known to be	is/are

it is clear that	clearly
reported in the literature	reported
subsequent to	after

Activity 26

Consider the suggestions for conciseness in table xxx. Revise the following passages by substituting the italicized phrases with more concise alternatives:

a. *Despite the fact that* the Lewis acid behavior of group 13 halides has been extensively studied,[8] the Lewis acid behavior of group 12 halides has not.[9] (Adapted from Borovik et al., 2001).

b. *In order to* explain this shift, they proposed that the smaller particles are more sensitive to UV curing *based on the fact that* their relative surface areas are larger. (Adapted from Bol and Meijerink, 2001)

Activity 27

Re-write the following wordy sentences concisely

In our judgment, this finding clearly demonstrates . . .(7 words)

Shorten it to 4 words

The results, as illustrated in Table x, suggest that . . .(9 words)

Shorten it to 6 words

The ethanol (research grade and purchased from Sigma-Aldrich, located in Milwaukee, Wisconsin) was added . . . (14 words)

Shorten it to 9 words

Activity 28

Revise these sentences. Identify the parts that you consider to be too wordy. Make those parts more concise or delete them entirely.

Example

Wordy: The lipid-binding potential was *observed to be* independent of pH; *as a consequence*, the results *presented in this paper* do not support hydrophobic interactions.

More Concise: The lipid-binding potential was independent of pH; hence, the results do not support hydrophobic interactions.

1. Prior to irradiation, the sample chamber was thoroughly flushed with nitrogen, to be sure that air was absent during the irradiation. (Adapted from Boland Meijerink, 2001).
2. It is possible that the products of the photochemical reaction that takes place upon irradiation in the presence of water passivate the surface better than the photooxidation products obtained during irradiation in dry air. (Adapted from Bol and Meijerink, 2001)
3. In consequence of this fact, it can be assumed that $ArCl^+$ does not interfere with the quantification of arsenic in the soil extracts.
4. In a large number of cases, cigarette s d. moke contributions could not be determined because the anteisoalkanes and isoalkanes that are used to trace cigarette smoke particles were below detection limits. (Adapted from Schauer et al., 2002)
5. Levels of all aldehydes increased during storage compared to the control sample, as exhibited in Figure 2. (Adapted from Vesely et al., 2003)
6. All of the chemicals were research grade, and they were all purchased from Fisher, which is located in Pittsburgh, PA.

Using Nominalizations

Another technique employed by chemists to achieve conciseness is to use nominalizations. Nominalizations are nouns that are formed from other parts of speech, usually by adding such endings as *-tion, -sion, -ment, -ity, -sis, and -ence.*

For example,

solubility (noun, from the adjective *soluble*)

distillation (noun, from the verb *distill*)

Nominalizations often allow several words to be summarized in a single word. For example,

Without a nominalization: After we distilled the product, it was a colorless liquid. (10 words)

With a nominalization: After distillation, the product was a colorless liquid. (8 words)

By using a nominalization in this example, it was possible to remove the word "we" from the sentence, making it sound more objective. The following list is common nominalizations used in chemistry journal articles

Common normalizations used in chemistry writing

absorption	aggregation	analysis	concentration
addition	reactivity	comparison	emission
agreement	conversion	reduction	formation
calculation	extraction	oxidation	preparation
activation	dependence	synthesis	treatment
measurement	intensity	presence	efficiency
diffusion	interaction	purification	precision

Activity 29

Rewrite the following sentences to make them more concise. (Do not delete original citations, indicated by superscript numbers.)

At this point in time, there exist only a small number of reported examples of the synthesis of carboranes from eneynes,[20] the first of these being the synthesis of 1-isopropenylcarborane.[21] (Adapted from Valliant et al.,2002)

Table Y accurately summarizes the reaction products from the two reactions that were performed: the hydrogenation reaction and the oxidation reaction.

Polyadducts of C_{60} with well-defined three-dimensional structures are of great importance, based on the fact that they possess interesting biological [1a] and material properties.[1b,c] (Adapted from Mas-Torrent et al., 2002)

4.2 **Writing a chemistry journal article**

In science in particular, where difficult concepts must be communicated, the quality of writing can "make or break" an advance. *Good scientific reports share many of the qualities found in other kinds of writing. To write is to think, so a paper that lays out ideas in a logical order will facilitate the same kind of thinking. Make each sentence follows from the previous one, building an argument piece by piece. Group related sentences into paragraphs, and group paragraphs into sections. Thus create a flow from beginning to end.*

Dear Learner, how many scientific journals are there? Why these journals are important? Take a moment to list out some journals and discuss their importance to the global population before reading the following paragraph.

There are thousands of scientific journals that publish research articles. These journals are diverse and can be distinguished according to their field of specialization. *All of these journals play a critical role in the advancement of science and dissemination of information.* However, to understand how science is disseminated through these journals, you must first understand how the articles themselves are formatted and what information they contain. While some details about format vary between journals and even between articles in the same journal, there are broad characteristics that all scientific journal articles share.

Overview of the journal article

In this section we will discuss the structure of a journal-quality paper, a paper suitable for submission to a refereed chemistry journal. **Refereed journals** include only articles that have made it through a rigorous peer-review process. In this process, a submitted manuscript is

critically reviewed by two or more anonymous reviewers. The reviewers are asked to judge both the scientific merit and writing quality of the manuscript. Authors are often required to revise their work before it can be accepted for publication. Once published, the journal article becomes part of the **primary literature** of chemistry. The primary literature is a permanent and public record of all scientific works, many of which are refereed journal articles. Scientific articles report new work for the first time that is why they are called *primary literature*. In contrast, articles or news stories that review or report on scientific research already published elsewhere are referred to as *secondary publications*.

Audience and Purpose of a chemistry journal article

The major purpose for writing a chemistry journal article is to share the results of original research with other chemists. The primary audience for a journal article is an expert one; readers are typically well educated and highly experienced in the subfield of chemistry addressed in the article. Because journal articles are written largely for experts, newcomers to the field (e.g., students or chemists exploring a new research area) are often frustrated by the advanced level of these articles. Details are often omitted that the non-expert reader would find useful. (If you find yourself in this situation, we recommend that you also consult related works written for a less sophisticated audience—textbooks, review articles, general science articles—to help you work your way through the journal article.)

Although the bulk of the journal article is written for experts, a few sections are often accessible to less sophisticated readers. For example, general or summative remarks in the abstract, Introduction section, and conclusions are often accessible to a scientific audience, allowing those readers to grasp the key concepts of the work.

Similarly, many chemistry journals include features (e.g., book reviews, editorials, and news articles) that are written specifically for scientific and general audiences.

4.2.1 **Organization of a journal article**

The *broad* organizational structure of the journal article can be signaled by identifiable sections and headings. In general, journal articles are divided into four major sections. These sections have the familiar names **I**ntroduction, **M**ethods, **R**esults, and **D**iscussion; collectively, this organizational structure is referred to as the **IMRD format**. In addition to these four major divisions, journal articles also include a title, abstract, references, and often acknowledgments. (Acknowledgments are required for works supported by a funding agency; otherwise, this section is optional.) On occasion, journal articles also include a section for conclusions, but more often conclusions are included at the end of the Discussion section.

Introduction section (I)

The Introduction section of a journal article identifies the research area and explains the importance of the research by:

- providing background information,
- citing and summarizing key literature in the field,
- pointing out what still needs to be studied, and
- introducing the reader to the work presented in the article.

The method section (M)

The method section is formally known as Materials and Methods or Experimental (Section) in chemistry journals and describes how the study was conducted.

The results section (R)

The Results section summarizes quantitative (and possibly qualitative) data collected during the study.

The discussion section (D)

In the Discussion section is where the authors interpret their data and suggest the larger implications and/or applications of their results.

In recent years, variations have appeared in the traditional IMRD format. For example, some journals include explicit headings for all four divisions, some use fewer than four explicit headings, and some use no headings at all. The sequencing of the headings also varies. For example, *The Journal of Organic Chemistry* typically places the Experimental Section at the end of the article, while the *Journal of the American Chemical Society* places the Experimental Section in a footnote. Interestingly, in the past, chemists were discouraged from combining the Results section (presentation of data) with the Discussion section (interpretation of data), yet today a combined Results and Discussion section is commonplace. Because every journal has slightly different requirements, it is important to read the "Information for Authors" for the particular journal to which you plan to submit your paper.

Hourglass Structure representation of IMRD

The IMRD format creates what is sometimes called the hourglass structure, a feature common to journal articles across many fields of academic research. The hourglass depicts the way in which the scope or specificity of the paper changes throughout its sections, as shown in Figure 4.2.

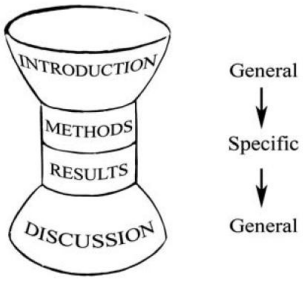


Figure 4.2 The hourglass structure of the IMRD format (adapted from Hill et al., 1982).

The Introduction section begins with a broad overview of the research area but narrows as the authors mention specifics about their presented work. This specificity is maintained throughout the Methods and Results sections and then broadens again at the end of the Discussion, where research findings are described in a broader context.

4.2.1.1 **Introduction**

The Introduction section is the first formal section of the journal article. It is often the first section to be read (by readers) but the last section to be written (by writers). This is because the Introduction must tell readers "where the article is going and why", a mission that is most easily accomplished after the rest of the sections have been completed.

By the end of this section, you should be able to:

- Describe the basic organizational structure of introduction section of an article
- Compose the all-important opening sentence of an Introduction
- Cite and summarize others' works in concise and appropriate ways
- Conclude your Introduction in an effective manner

The Introduction section, as its name implies, sets the stage for the rest of the journal article by introducing the research area, describing its importance, and hinting at what new knowledge and insights the authors have gained. The Introduction is also where authors summarize others works; this involves several important writing skills such as paraphrasing, writing concisely, and correctly citing the literature.

Introduction section is to:

- To clearly state the purpose of the study.
- To allow readers to understand the background to the study, without needing to consult the literature themselves.
- To indicate the authors who have worked or are working in this area, and to describe their chief contributions.
- To indicate correlations, contradictions and gaps in the knowledge, and to outline the approach the author will take with respect to them.
- To provide a context for the later discussion of the results.

The Introduction begins with the most general information (the research area) and gradually shifts to a more specific focus (the current work), preparing the reader for the highly specific focus of the Methods section. This transition from general to specific is the type depicted by the

hourglass shape of the journal article. The organizational structure for the Introduction section is likely the most consistently followed and the structure is presented in Figure 4.3.

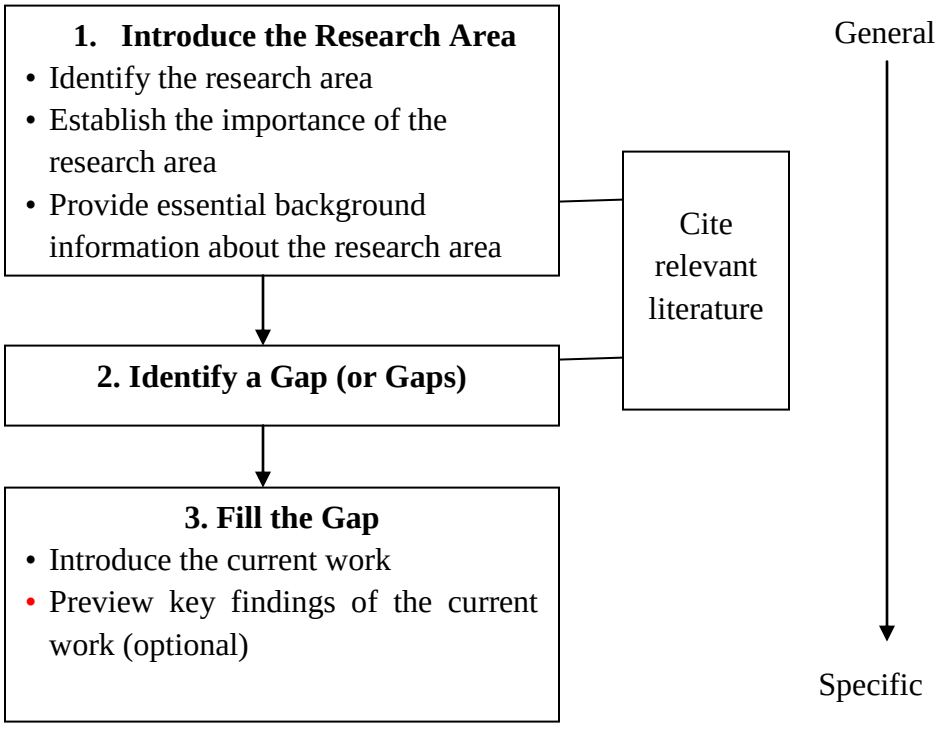


Figure 4.3 The structure of a typical introduction section

A. Introduce the Research Area

The research area is described broadly. This step is initiated and often accomplished in the opening sentence of the paper. This all-important first sentence is used to set the tone for the work. However, in chemistry journal articles, the first sentence tells the reader, with a broad stroke, what the story is about. Consider the following examples, in which the general topic is mentioned at the start of each sentence:

- Chromium is a metal widely distributed in soil and plants.
- Polychlorinated biphenyls (PCBs) are a group of pollutants widely distributed in the environment due to their generous use in the past, their lipophilic character, and their chemical stability.

Two writing features are worth pointing out regarding the opening sentence of a journal article. 1) The topic is usually introduced in the present tense; 2) Citations to the literature are quite common in the first sentence.

When authors cite others' works to establish the importance of their own work, or to provide background information, they frequently use present tense. This might be surprising because, after all, the cited works were done in the past; yet, the importance of the work is expected to be true today and into the future. Consider the following example:

> This functional group *has* roles in coordination chemistry as a ligand, in medicinal chemistry as a metabolically stable surrogate for a carboxylic acid group, and in various materials science applications, including specialty explosives.

Present perfect is typically used to signal that the knowledge gained from work completed in the past is still believed to be true in the present. In addition to present tense, another verb construction is commonly used when citing others' works. Consider the following sentence:

> In numerous studies, Cr^{6+} compounds *have been shown* to be carcinogenic in vivo and mutagenic in vitro. (From Plaper et al., 2002)

The construction "have been shown" is an example of a verb form known as present perfect. There are two forms of the present perfect:

Present perfect–active *has shown, have shown*

Present perfect–passive *has been shown, have been shown*

Present perfect is typically used to signal that the knowledge gained from work completed in the past is still believed to be true in the present

Table 4.3 Examples of active and passive constructions in present perfect

Active Voice: has/have + past participle	Passive voice: has/have+been+past participle
Has demonstrated	Has been demonstrated
Has recognized	Has been recognized
Has shown	Has been shown
Have discovered	Have been discovered
Have observed	Have been observed
Have received	Have been received

B. Identify a Gap

After the importance of a research area has been identified and the relevant background information has been summarized, the Introduction section shifts from a focus on what has been done (or learned) to an emphasis on what remains to be done (or learned). This change in emphasis is signaled with a gap statement. The gap statement points out what is lacking in the field and, in so doing, infers the next step that needs to be taken.

Example:

> Because soil bioremediation needs months to years depending on type and concentration of the contaminants, soil properties, and microflora, an additive that degrades slowly in the soil is required.
>
> [Next step: Find slowly degrading bioremediation additives.]

Table 4.4 lists gap statements useful for pointing what is lacking in the field. (X represents what has been done, learned, or understood; Y represents what needs to be done, learned, or understood.)

Table 4.4 Statements useful to indicate research gap

Type	**Example**
A question that remains unanswered	Numerous questions remain unanswered about Y.
A research area that remains poorly understood	Although much has been learned about X, Y remains poorly understood.
A next step that needs to be taken	The next step is to apply X to the study of Y.
An area that has yet to be studied	X has been the subject of several studies; however, to our knowledge, no studies on Y have been reported.
A procedure that needs to be improved (made less expensive, simpler, more efficient, etc.)	Although X achieves the desired detection limits, the method is costly and time consuming.
A new hypothesis or observation that needs to be validated	Additional studies are needed to corroborate these findings.

C. Fill the Gap

After the gap has been established, the last part of the Introduction section focuses on how to fill the gap. The authors must show how the current work takes at least a small step forward toward addressing the specified need, problem, or lack of knowledge in the field. The start of the *Fill the Gap* is commonly signaled with a new paragraph and a phrase such as "In this paper," or "In this work, we . . .". Following this phrase, the authors go on, typically in a sentence or two, to tell the readers about the current work, The phrases are often followed by the personal pronoun *we* (e.g., In the present study, *we* . . .). In such instances, *we* is used to signal the beginning of the authors' presented work in the journal article.

List of some common phrases used to mark transition from *identification of gap* to *fill the gap* in the introduction section:

In the present study,	In this context,	In this study,	In this paper
In the present work	In this investigation	In this work	Herein,

Table 4.5 lists some verbs that typically follow *we* in the fill-the-gap statement.

Table 4.5 Common verbs that follow *we* in the fill-the-gap statement of the Introduction section.

In this work, we (present tense verbs)	In this work, we (past tense verbs)
carry out	analyzed
demonstrate	calculated
describe	chose
develop	determined
employ	employed
present	examined
propose	focused on
provide	found
report	investigated
show	measured
use	solved
	studied
	synthesized

4.2.1.2 **Materials and methods**

> *Tell me how you did it, but be concise. A long-winded step-by-step Methods section sidetracks and irritates the expert reader.*
>
> —Betty H. Stewart, Midwestern State University

Section Objective:

By the end of this section, you will be able to do the following:

- Know how to address the intended audience of a Methods section
- Recognize which details to include and exclude from a Methods section
- Organize a Methods section following standard flow of ideas
- Use capitalization, abbreviations, and parentheses appropriately
- Format numbers and units correctly

- Use verb tense and voice in conventional manners

In this section we will focus on writing a Methods section for a journal-quality paper. This is the section that many chemists write first, in part because this section describes what they know best: the procedures they have repeated (many times) to conduct their work. Moreover, most research groups use similar methodologies for several years; hence, previously written Methods sections can serve as models for writing new methods sections. This makes it one of the easiest sections to write and an excellent place to begin for writing.

The purpose of the Methods section is to address *how* a particular work was conducted. Relevant information about instrumentation and experimental and/or numerical procedures is described. The goal is to describe the information in enough detail that an expert (not a novice) could repeat the work. Usually, this section is formally called, for example, **Materials and Methods** or **Experimental Section**, in addition to the **Methods section**.

The major purpose of a Methods section is to describe, for other chemists (the audience), the procedures that were used to obtain the results presented in the article. A well-written Methods section serves as a resource for expert chemists who wish to (1) develop similar procedures, (2) compare their own procedures with those presented, or (3) familiarize themselves with procedures in a branch of chemistry other than their own. Because Methods sections of journal articles are written largely for experts, they are not at all like Methods sections of chemistry lab reports.

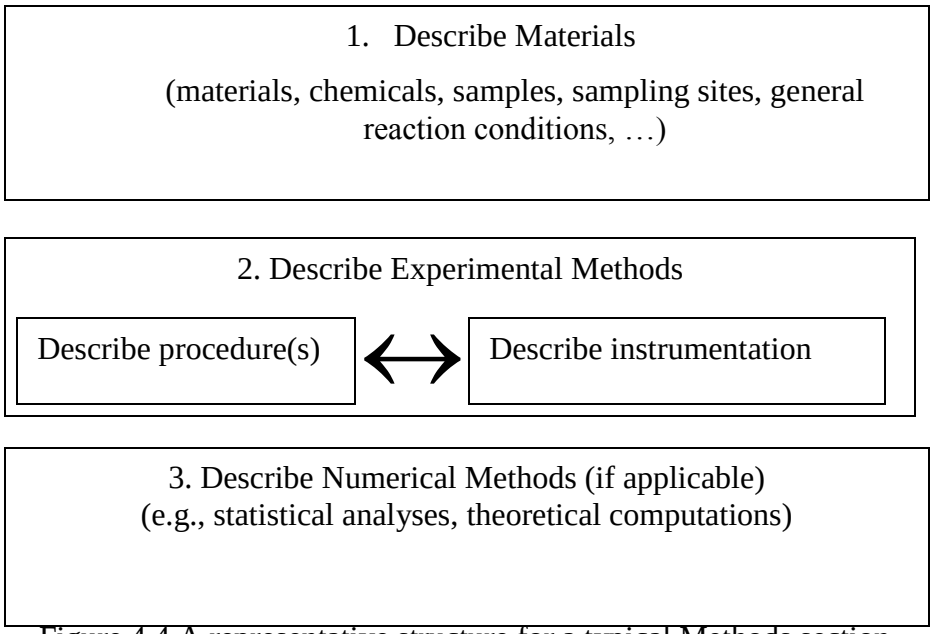


Figure 4.4 A representative structure for a typical Methods section

Lab reports are written largely for instructional purposes, to reinforce new techniques and help students carry out experiments successfully. As such, they tend to include details (e.g., lists of equipment, safety precautions, and step-by-step directions) not needed (or wanted) by expert readers.

The method section of chemistry article leaves out such details making the writing more concise. Concise writing is important because, unlike a single lab experiment, methods sections in journal articles describe multifaceted works that took months or years to complete. Similarly, lab reports often include language inappropriate for journal articles. For example, in the Methods section of a lab report, a student might write "Stir mixture. Heat to reflux." In a journal article, however, this would be restated in past tense and passive voice as "The mixture was stirred and heated to reflux," making the writing more formal.

Activity 30

You have been writing Laboratory reports for many chemistry practical courses you have been taking. After you did the experiments, you were writing laboratory reports. In the report, the methods used (formally called procedure) is one of the sections you have to write.

What information you were trying to include in the procedure section?

What kind of tense you were using (present tense, past tense, active voice or passive voice)?

Do you think the method section of an article to be similar in style and depth of information with that of laboratory report procedure part? If you say they should differ, why?

How to Describe Procedures?

Activity 31

Many of you have already described procedures in a lab report. Most likely, you included items such as the equation that you used to calculate percent yield or the step-by-step instructions that you followed to complete a synthesis (e.g., "Heat to reflux." or "Stir constantly for 10 min."). Are such items also appropriate in a journal article?

To answer this question, let us consider an example (adapted from Demko and Sharpless, 2001).

> ***Large-Scale, Organic Solvent-Free Procedure for the Synthesis of Tetrazoles.*** *To a three-necked 2 L round-bottomed flask equipped with a mechanical stirrer was added benzonitrile (103.1 g, 1.00 mol), 1 L water, sodium azide (68.2 g, 1.05 mol), and zinc chloride (68.1 g, 0.50 mol). The reaction was refluxed in a hood, but open to the atmosphere, for 24 h with vigorous stirring. After the mixture was cooled to room temperature, the pH was adjusted to 1.0 with concentrated HCl (~120 mL), and the reaction was stirred for 30 min to break up the solid precipitate, presumably* $(PhCN_4)_2Zn$*. The new precipitate was then filtered, washed with 1 N HCl (2 x 200 mL), and dried in a drying oven at 90 ℃ overnight to give 98.0 g of 5-phenyltetrazole as a white powder (67% yield, mp 211 ℃ (lit. 216 ℃) …*

Note the following features:

- Describing the method section begin with a subheading. The subheading refers to a general procedure for synthesizing a class of compounds (tetrazoles). The excerpts then go on to describe the steps in the synthesis.
- Scientists most often use the numerical form for numbers (e.g., 5) rather than the word form (e.g., five). Indeed, the numerical form is always used with units of time (e.g., s, h,

min, days, weeks, years) and measure (e.g., mL, cm, m3, g, K), unless the number starts the sentence. Note, too, that there is a space between the number and the unit.

Incorrect	2mL	0.6cm	4.2ft	0.015mg	8K	180°C	180° C
Correct	2 mL	0.6 cm	4.2 ft	0.015 mg	8 K	180 °C	

A notable **exception** to this rule occurs with percentages; in this case, there is no space between the number and the percent sign (%):

Incorrect	85 %	eighty-five %	eighty-five%
Correct	85%		

Units of Measure

Measure is a general term that implies units of

- ✓ volume (mL, cm^3)
- ✓ width or length (m, cm)
- ✓ mass (g, mg)
- ✓ temperature (°C, K)
- ✓ concentration (g/mL, M)

Occasionally, the word form of a number is preferred. For example, words are used for whole numbers less than 10 (e.g., nine flasks), except when the number refers to time or measure (7 s, 5 mL). The numerical form is used for numbers 10 or greater (e.g., 10 flasks, 10 samples, 25 trees, 100 cm).

Incorrect	five cm	6 fractions	3 samples	thirteen sites
Correct	5 cm	six fractions	three samples	13 sites

The word form is also used for numbers that start a sentence, unless the number is part of a chemical name. Whenever possible, however, rewrite the sentence so that it does not begin with a number. Units are spelled out following a number in word form and the plural verb is used

(e.g., Ten milliliters were . . .). A sentence that begins with a spelled-out number reverts back to numerical form, when appropriate, in the rest of the sentence. Consider the following examples:

Correct	*2*-Butene was purchased from Aldrich.
Correct	*Eleven* hazelnut oils, *25* olive oils, and *7* other types of oil were purchased.
Correct	*Two grams* of NaCl were shaken for *20* min with *20* mL of ethanol.
Better	NaCl (2 g) was shaken for *20* min with *20* mL of ethanol.

There are literally hundreds of units commonly used in chemistry. Some important rules about using numbers and units are summarized below:

- ✓ Abbreviate units of measure when they come after a numeral:

  A degassed solution of 312 mg (1.39 mmol) . . .

- ✓ Do not abbreviate units of measure that do not follow a numeral:

  . . . several milligrams Twenty percent . . .

- ✓ Leave a space between a numeral and its unit of measure, unless the unit of measure is a percent sign (%):

  Examples: 0 °C 600 g 95%

- ✓ Do not add "s" to make an abbreviated unit of measure plural:

  Example: Incorrect 20 mgs

  Correct 20 mg

- ✓ Include a leading zero with numeric decimals:

  Example: Incorrect .6 mg

  Correct 0.6 mg

- ✓ When using symbols such as <, >, and ±, include spaces between the numbers and symbol if there are numbers on both sides of the symbol. Also include spaces if the symbol falls in between a variable and a number:

  Example: Incorrect > 60 g 35±2% *P*<0.05

  Correct <25 mL 80 ± 9% ee > 99%

- ✓ Use numerals in a series or range containing numbers 10 or greater to maintain parallelism (even if smaller numbers would be written out in other circumstances):

  Example: Incorrect three, seven, and 14 samples

  Correct 3, 7, and 14 samples

- ✓ Correctly formatted abbreviations, numbers, and units are an essential part of scientific writing. Formatting is the author's responsibility, and it is not the responsibility of peer reviewer, or journal editor. If you are not sure how to format a number or word correctly, consult *The ACS Style Guide* and look for instructions to authors in your journal of interest.

Activity 32

Correct the following (incorrect) uses of numbers and units. Assume that these numbers and units are not being used to start sentences.

Incorrect	7minutes	.15 mg	five percent yield	12 hrs.
Correct	_____	_____	_____	_____
Incorrect	10min.	0.175g	7 % recovery	13 hr.
Correct	_____	_____	_____	_____
Incorrect	15 mLs	5 sec.	100° C	300° K
Correct	_____	_____	_____	_____

Describe instrumentation

Authors must also describe the instrumentation or scientific apparatus that they used in their work. (Note that ordinary equipment, e.g., a distillation apparatus or a rotary evaporator, should not be described.) Instrumentation generally falls into two categories: custom-built or commercial. Custom-built instrumentation includes novel or hand-built chambers, devices, or instruments. The first publication that describes a custom-built instrument offers the most detail and often includes a diagram. Subsequent publications briefly highlight the essential features of the apparatus and refer the reader to the original article for more information.

Plural of Apparatus

The word *apparatus* has two plural forms: Apparatus and apparatuses. *The ACS Style Guide* recommends *apparatus* as the preferred form.

Descriptions of Apparatus

The ACS Style Guide specifies that an apparatus should be described only if it is not standard or not available commercially. With standard, commercially available apparatus, stating a company name and model number in parentheses is appropriate and adequate. Common instruments are standardized that no instructions or diagrams are needed to explain how they work. It is necessary, however, to report the operational parameters (The conditions (settings) under which a particular instrument is operated) under which an instrument was operated. Parameters are selected and optimized for each particular application of an instrument and can vary among users, even for the same instrument. Moreover, parameters affect the outcome and reproducibility of an experiment; hence, they must be described.

Activity 33

With which of the following instruments should you include a diagram of the instrumentation in a Methods section? Why?

a) 1H NMR instrument (400 MHz)

b) a reflux apparatus

c) a Soxhlet extraction apparatus

d) a Nicolet 870 FTIR spectrometer with an attenuated total reflectance (ATR) accessory

e) a new nozzle design for an ICP mass spectrometer

Describe Numerical Methods

The final move of the Methods section involves the description of statistical, computational, or other mathematical methods used to derive or analyze data. This is required only if numerical methods were part of the work. In writing numerical methods, subheadings are also used to guide the reader's attention to this information. Note that when specialized statistical software is used, the name and version number of the software package are reported. Important statistical parameters that affect the outcome of the statistical test (e.g., significance level) may also be reported in the Results section. Note that routine

software such as Microsoft Word or Excel should not be reported in this section (or anywhere else in the journal article).

Analyzing Writing across the Methods Section

Two writing conventions apply to the Methods section as a whole: the use of tense (past or present) and voice (passive or active). Past tense and passive voice predominate in the Methods section; however, in some cases, present tense and/or active voice are also used. Like other writing conventions, the proper use of tense and voice reveals authors' familiarity with the expectations of the field, their objectivity, and more expert-like writing abilities.

A) **Past and Present Tense**

The Methods section is largely written in the past tense. In general, the Methods section describes work that was done in the past, making the past tense the appropriate choice. This is different from a lab manual, which gives a set of instructions in the present tense.

Examples: (Lab manual) Stir the mixture, heat to reflux.
(Journal article) The mixture was stirred and heated to reflux.

Although the Methods section is overwhelmingly written in the past tense, there are few correct instances of present tense. The general rule of thumb for deciding when to use past or present tense in the methods section (and elsewhere in the journal article) is as follows:

Work was done in the past; knowledge exists in the present.

Work done in the past is described using past-tense verbs (e.g., analyzed, built, heated, investigated, isolated, measured, performed, synthesized, tested). Knowledge that exists in the present (and presumably into the future) is described using present-tense verbs (e.g., contains, defines, describes, explains, implies, is expected to, provides, suggests). Present tense is also used to describe fixed features of a custom-built instrument (e.g., length and width). Consider the following examples. In each case, the past tense describes actions taken by the researchers that led to their results; the present tense describes information that is expected to be true over time.

Past tense The water *was* triply distilled.

Present tense	Triply distilled water *contains* less than 1 ppb of the impurity.
Past tense	Height measurements *were* taken using a nanoscope.
Present tense	Height data *provide* topographical information.
Past tense	Helium gas *was* used to purge the chamber.
Present tense:	The outer diameter of the chamber *measures* 10 cm.

Passive and Active Voice

The Methods section is also written largely in passive voice. Passive voice is most often combined with past tense:

Examples:

Inappropriate	We heat the mixture to 80 °C. [Present tense, active voice]
	We heated the mixture to 80 °C. [Past tense, active voice]
	The mixture is heated to 80 °C. [Present tense, passive voice]
Appropriate	The mixture was heated to 80 °C. [Past tense, passive voice]

You may have been taught in other writing courses not to use passive voice because it is considered "weak." However, passive voice, when used appropriately, strengthens writing in chemistry journal articles.

Note that passive voice is used in all sections, but it is most common in the Methods section. Passive voice is preferred because it sounds more objective. Passive voice essentially removes the human subject (i.e., the scientist) from the sentence so that the focus of the sentence is the object that was acted on.

Examples:

Active	We added solid Se (0.030 g) to the pale orange solution.
Passive	To the pale orange solution was added solid Se (0.030 g).

Active	We stirred the mixture for 10 min at room temperature.
Passive	The mixture was stirred for 10 min at room temperature

Activity 34

Rewrite these sentences so that they are more appropriate for the Methods section of a journal article; use passive voice and past tense:

a) We recrystallized the product from ethanol in a fume hood.

b) We measured the temperature with a K-type thermocouple located just above the catalyst bed.

c) Filter the precipitate. Wash three times with 10 mL of ethanol each time.

d) Add chlorosulfonic acid (0.350 mL) dropwise to a fl ask containing acetic acid in an ice bath.

e) We used a Nicolet model 590 FTIR spectrometer to analyze the water-ice films.

f) We collected all of our samples in amber glass bottles with Teflon-lined caps (EPA level 1, 33 mm, VWR).

g) We used the Box-Hunter program run under MAPLE computer algebra software (v. 5, Waterloo Maple, Inc.).

Checklist while writing the method section

- Understand your audience and be concise (Are you writing for an expert audience, leaving out unnecessary details
- Organization of text (Check your overall organizational structure, did you included appropriate subheadings? Do your experimental procedures clearly convey the order followed in your work (without using ordinal language)?
- Writing conventions: Check to be sure that you have used voice (mostly passive) and tense (mostly past tense) correctly. Check your formatting of units and numbers, use of abbreviations and acronyms, and capitalization of compounds and vendors.
- Grammar and mechanics: Check for typos and errors in spelling, subject–verb agreement, punctuation, and word usage (e.g., effect vs. affect, data).
- Science content: Have you correctly conveyed the science in your work? Have you used words and units correctly? If asked, could you define all of the words that you have used? Do you understand, in principle, how the instruments described in your methods section work?

After thoroughly reviewing and revising your own work, it is common practice to have your work reviewed by a peer or colleague. A "new set of eyes" will pick up mistakes that you can no longer see because you are too familiar with your own writing.

 **Self-test Exercise**

As a review, try explaining the following to a friend or colleague who has not yet tried to write a Methods section for a journal article:

Main purpose of a Methods section

- Guidelines for spelling out abbreviations in a Methods section
- Guidelines for the inclusion of an illustration of an apparatus in a Methods section
- Guidelines for conveying the order of events in a Methods section
- Appropriate use of numbers and units in a Methods section
- Use of tense (past/present) and voice (active/passive) in a Methods section

4.2.1.3 **Results**

> *In Results and Discussion sections, the reader should be led step-by step through the subject, showing how conclusions unfold logically as the results accumulate.*
>
> —Charles H. DePuy, University of Colorado–Boulder

This section focuses on the Results section of the journal article. The Results section makes use of both text and **graphics (**figures, tables, and schemes) to highlight the essential findings of a study and to tell the story of scientific discovery.

Section objectives:

After completing this section, you should be able to:

- Distinguish between the description and interpretation of data

- Organize and present your results in a clear, logical manner and appropriately refer to a figure or graph in the text
- Use appropriate tense, voice, and word choice in writing Result section of an article

The purpose of a Results section (the third section in the standard IMRD format) is to present the most essential data collected during a research project. A well-written Results section guides the reader's attention back and forth between text and graphics while highlighting important features of the data and telling the story of scientific discovery. Months (possibly years) of accumulated knowledge and wisdom, and countless pages of data, are distilled into only a few pages; hence, only the essential threads of the story are included in the Results section.

In many journal articles, the Results section is actually a combined Results and Discussion (R&D) section. Combined R&D sections are preferred by many scientists who want to present and discuss results in an unbroken chain of thought. The combination is often more concise because less time is spent reminding the reader which results are being discussed. Combined R&D sections can be either of the following patterns: blocked R&D, iterative R&D, or and integrated R&D.

a) **blocked R&D** pattern, a single block of results is followed by a single block of discussion. For example, for a set of three results, the pattern would be
   [results 1, results 2, results 3] [discussion 1, discussion 2, discussion 3].
   The blocked R&D pattern is identical to that of fully separate sections but merged under a single "Results and Discussion" heading. In such papers, it is usually quite easy to determine where the Results section ends and the Discussion section begins.
b) In the **iterative R&D** pattern (the most common pattern), authors alternate between presenting and discussing results. Thus, for three results, an iterative R&D pattern is achieved as follows: [results 1, discussion 1] [results 2, discussion 2] [results 3, discussion 3].
   The story of scientific discovery is often easier to tell (and understand) if each finding is presented and discussed before moving on to the next.
c) With the **integrated R&D** pattern, results are presented and discussed together, often in the same paragraph or even the same sentence. The text is organized in a way that best

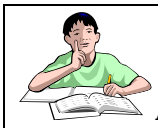
conveys the story of scientific discovery, with no obvious delineation between results and discussion. This pattern is less common, but when done well is quite effective.

These patterns are intended to serve as guiding constructs only. In practice, most authors who use combined R&D sections will combine features of two or three patterns in their writing, making it difficult to find a pure example.

Analyzing Audience and Purpose

The American Chemical Society, *Ethical Guidelines to Publication in Chemical Research states that "An author's central obligation is to present an accurate account of the research performed as well as an objective discussion of its significance".* The central purpose of the Results section is to describe your research findings to other scientists (an expert audience) in a clear and concise manner. The distinction between description (Results) and interpretation (Discussion) is not always clear-cut. The following guideline may help to distinguish between the two:

An objective description of results allows readers to examine the data unbiased by interpretation. Results are sometimes viewed as a hint at the "truth"; alternatively, interpretations are educated opinions that are likely to change over time.



Activity 35

Which of the following statement is used to describe experimental result?

Which of the following statement is interpretation of an experimental result?

a) The ethanol solution spiked with 5 ppb of methanol was exposed for 15, 30, 60, 90, and 120 min at 50 °C.

b) The higher coefficient of variation for (*E*)-2-nonenal may be due to extremely low levels of this aldehyde in the analyzed beer.

c) The highest content of rutin, 2.5–3% of dry weight, was observed as sampling started.

d) Trends in rutin content were rather similar in all of the buckwheat varieties, indicating a more important influence of environment than genotype on the rutin content of the buckwheat herb.

e) On the basis of this study, it is clear that buckwheat herb production is feasible and that it could readily be produced as a nutritionally rich food, a rutin-rich herb tea, or food additive.

Analyzing Organization

The purpose of the Results section is to present—without interpretation—the results of the study. To accomplish this task, first set the Stage that serves to transition the reader from the Methods to the Results section. Then the reader is briefly reminded how a particular set of results was obtained, and also the reader is referred to a graphic (a table or figure) that displays those results. These complementary steps are often accomplished in a single sentence. After the graphic has been introduced, the authors shift to telling the Story of Scientific Discovery, where important findings are identified, trends are highlighted, and unexpected results are underscored. Importantly, the story is rarely told in the way that it actually occurred (chronologically); rather, it is told in a way that logically leads the reader to the conclusions of the paper. This style of writing is repeated, as needed, for each set of results.

The best way to learn how to write a Results section is to read and analyze Results sections from the literature.

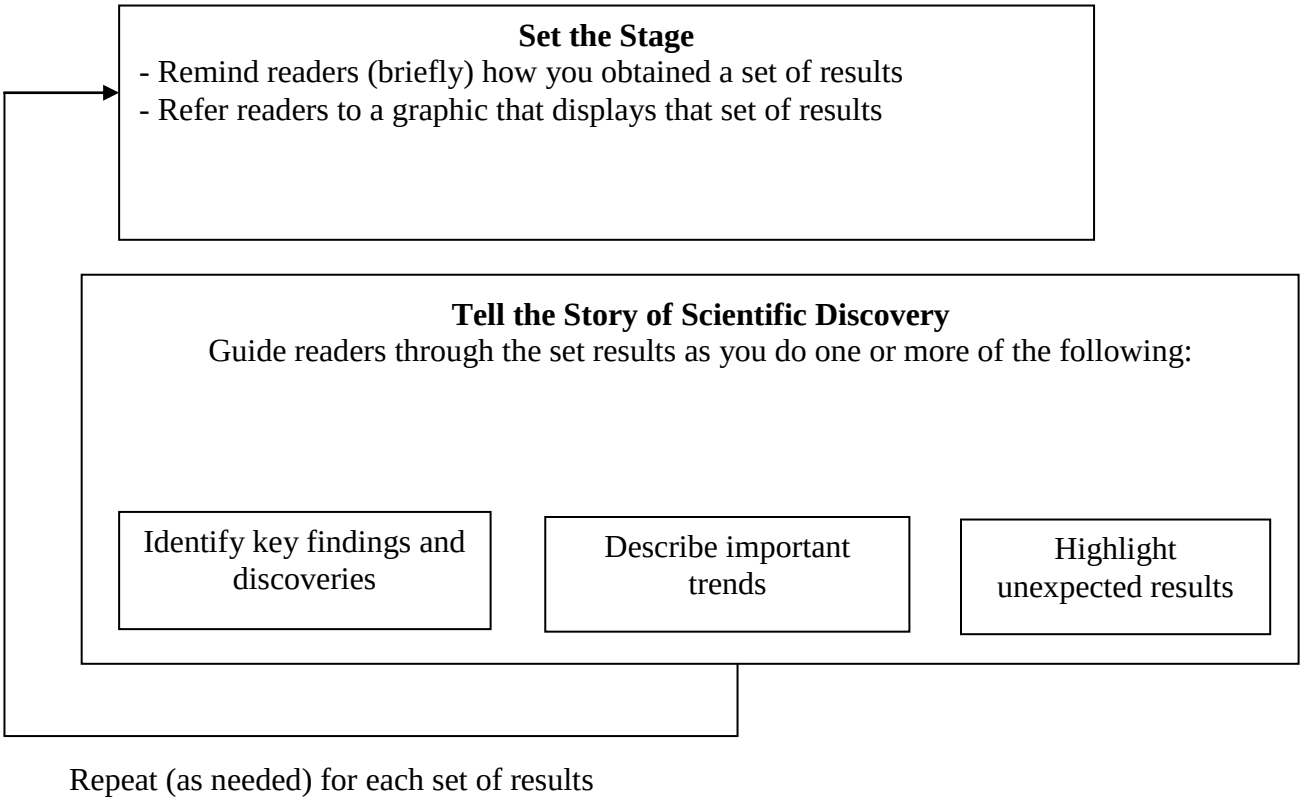


Figure 4.6 Typical structure of a result section of an article

Sets of Results

Results sections often include multiple sets of results. Each set presents a different piece of evidence or a different part of the project. The various sets are linked to lead logically to the conclusions of the paper.

Characteristic of the results section verb tense, voice, and word choice

Past and Present Tense

Unlike the Methods section, which is written primarily in past tense, both past and present tense are used in the Results section. In general, present tense is used (1) to refer the reader to a figure or a graph and (2) to make statements of general knowledge expected to be true over time.
Passive voice is used more frequently in Methods sections than in Results (or Discussion) sections. This distribution suggests that both active voice and passive voice are used in Results sections. Past and present tense, when combined with active and passive voice, form four different tense–voice combinations. Each combination has its own function, several of which are illustrated in table 4.6.

Table 4.6 Common functions of different verb tense–voice combinations in Results sections

Function	Tense–Voice Combination	Example
To describe specific results in your work	Past–active	Other combinations of alcoholic solvents *failed* to lead to a higher yield.
To describe specific steps in your work	Past–passive	Initial HSSPME experiments *were performed* using spiked skimmed and full-fat milk samples.
To state scientific "truths" or knowledge	Present–active	PCBs *are* more strongly retained in the sample matrix as the fat content *increases*.
To refer to a fi gure or table	Present–active	Figure 1 *shows* as an example the mass spectrum of the PFBOA derivative of

		methional.
	Present–passive	Experimental adsorption isotherms for the RAMEB-treated soils *are presented* in Figure 1.

"We" in the R&D Section

The use of the word *we* is quite rare. The most compelling reason to use *we* in the Results section is to highlight a decision or choice made while conducting a work. *The ACS Style Guide* advises against using phrases such as "we believe", "we feel", and "we can see".

Activity 36

Consider the most compelling reasons for using *we* in a Results section. For each passage below, decide whether the use of *we* is appropriate. Explain each decision.

A) The As and Pb concentrations *we* obtained for the 83 samples are reported in Table 3. *We* note from Table 3 that the range of As and Pb concentrations in the two populations is quite distinct

B) *We* use the term *K*D, the distribution coefficient, in the following discussion, although equilibrium may not have been achieved in all cases.

C) To reduce the problems of ligand-specific bias, *we* developed a modified rating for each molecule. *We* have called this corrected score the multiple active site correction rating (MASC).

Use of "Respectively"

The word *respectively* (meaning "separately, in the order specified") often appears in science writing and can be used to make your writing more concise. Generally, *respectively* appears at the end of the sentence; on rare occasions, however, it appears within the sentence. Note, too, that when two or more items have the same unit, the unit is stated only once.

Example: The concentrations of 2-ABP, 3-ABP, and 4-ABP in PPD were estimated at 70, 310, and 500 ppb, *respectively*.

Activity 37

Compare the following sentences with and without the word *respectively*. What is the advantage of using the word *respectively*?

A was measured at X ºC, B was measured at Y ºC, and C was measured at Z ºC.

Compare it with:

A, B, and C were measured at X, Y, and Z ºC, respectively.

The use of the word *respectively* helps achieve conciseness. More important, it aids clarity. By grouping values together, trends in the data are easier to discern. To ensure that the correct meaning is conveyed when using *respectively*, it is crucial that the order of the first set of items (e.g., A, B, C) parallels the order of the second (e.g., X, Y, Z).

Use of Quantitative Language

It is advisable to describe your experimental results with quantitative terms. As mentioned above, a Results section is descriptive, not interpretive.

Activity 38

Which of the following experimental results are correctly described using quantitative terms?

At times, the

A) Heating the mixture to 93 °C gave very good yields.

B) Heating the mixture to 93 °C gave high yields.

C) Heating the mixture to 93 °C gave a 98% yield.

D) The solution was very acidic.

E) The pH of the solution was 1.2.

Activity 39

Rewrite the following sentences to be more descriptive by using precise quantitative terms.

A. Because of the high acidity of the water, samples were collected in an appropriate container.

B. The measured signal was very high at low pH conditions.

C. Although GC/MS has been used on similar samples before, our preconcentration technique afforded a significant increase in sensitivity for the brominated compounds.

Correct use of Scientific Plurals

The word *data* is commonly misused by writers; the mistake involves using *data* as a singular noun. In nearly all instances, the word *data* is plural and should be used with a plural verb:

Incorrect: Data is . . .

Correct: Data are . . .

4.2.1.4 **Writing the discussion section**

> *Chemists should seek to advance chemical science, understand the limitations of their knowledge, and respect the truth. Chemists should ensure that their scientific contributions, and those of the collaborators, are thorough, accurate, and unbiased in design, implementation, and presentation.*
>
> —The Chemist's Code of Conduct (www.chemistry.org)

This section is the last part of the standard IMRD structure for a journal article. The Discussion section can stand alone or can be part of a combined Results and Discussion (R&D) section.

In either case, it serves the same major purpose: to interpret the results of the study.

After completion of this section, you should be able to:

- ✓ Write an organized discussion section.
- ✓ Interpret your results by describing the greater importance of your findings.
- ✓ Apply appropriate writing conventions for writing discussion section.

In the Discussion section of a journal article, authors interpret their data, address *why* and *how* questions. Ideally, the Discussion section explains the story revealed by the data, postulates reasons for the observed behaviors, and furthers our fundamental understanding of the underlying science.

Although interpretation is the primary goal of the Discussion section, authors must be careful not to:

- over interpret their data.
- misinterpret their results.
- overstate their assumptions.
- Stray too far from scientific evidence.

The Discussion section of a journal article is used to interpret or explain results presented in the paper and to propose broader implications of these findings. The interpretation of results is typically written for an expert audience whereas the broader implications of the work are typically accessible to a scientific audience or even a general audience. This shift in audience completes the hourglass structure of the IMRD format. The Discussion section forms the bottom of the hourglass; it begins with a specific focus but ultimately expands to offer a more general perspective.

Organizational structure of Discussion section

As shown in figure xxx the Discussion section is organized around two important points: Discussing Specific Results and Concluding the Paper. While discussing specific results, the writer has to remind readers about the result that will be discussed, serving as a transition between the Results and Discussion sections. Such a reminder is often not needed in a combined R&D section but is necessary in a stand-alone Discussion section. Its purpose is to draw the reader's attention to a particular finding, not to restate all of the results. This has to be accomplished in only a few sentences. Once the transition has been laid, then the writer has to move to:

- Propose mechanisms
- Elaborate results
- Postulate why or how a particular behavior was observed.

Whenever possible, references to relevant literature should be included as part of the discussion section to support the ideas reflected. In particular, references that provide additional insights, refute an argument, or **corroborate** the findings at hand should be cited. This helps to connect the work to a larger body of evidence, moving toward the ultimate goal of scientific consensus. Paralleling the order of the results, this trend could be repeated for each set of the results. The last section of discussion section signals the conclusion of the paper. A separate section to draw the conclusion can be used or the phrase *In conclusion* or *In summary* at the start of a paragraph may be use to mark the conclusions. The results section also is used to briefly summarize the work, highlighting the **take-home message(s)** of the paper. This is followed by a brief narrative that suggests implications and/or applications of the work and addresses at least one of the following questions:

- What are the implications of the work?
- What new insights were gained?
- How has this work increased our fundamental understanding of the research area?
- What are the practical applications of this work?
- How will the work affect society (e.g., industry, medicine, technology, the environment)?

To answer these questions, authors must look beyond the specific details of their own work and focus instead on the broader goals of the research project. Attaining this broader outlook can be challenging, especially for students who spend most of their time focused on only a small part of a larger project. Over time, however, your grasp of the broader picture will improve as you continue to read the literature, attend seminars and conferences, and read and write research proposals in your area of research.

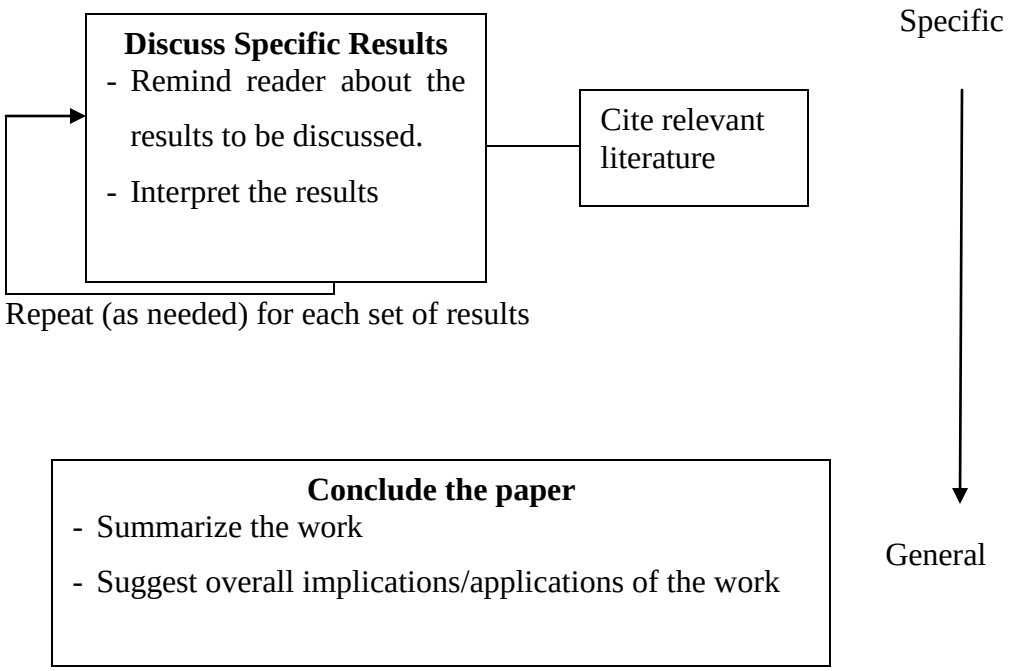


Figure 4.7 Structure of a typical discussion section of a journal article

4.2.1.5 **Other sections of a scientific report**

The title of a scientific report

Activity 40

What is the main purpose of title of a document?

The main purpose of title is to:

- Adequately describe the contents of your document in the fewest possible words.
- Give the reader immediate access to the main subject matter.

Devising a title to a document is difficult as it should be short enough, contains all the key information and makes sense (i.e. should not be ambiguous, is not syntactically problematic) Characteristics of a title:

- It should be not too general, not too detailed, and should contain the necessary key information.
- After making it short, be sure that it makes sense as the structure can be lost during the quest for the minimum number of words,

Tips for writing journal paper title

- Think along the lines: 'How would I look for this kind of information in a database?' Many papers are selected for reading from the titles as they appear in a List of References. An inadequate title may not be followed up.
- Avoid a general title. Make sure that it contains all the information that you would look for when deciding whether or not to read a paper.

Activity 41

Compare the following Titles and reflect their quality in terms of conciseness of the title, clarity of the information delivered and the specificity of the message to be conveyed.

Selective Extraction of Metals from Mixed Oxide Matrixes Using Choline-Based Ionic Liquids

Electrochemical analysis with nanoparticle-based biosystems

Selective oxidation of glycerol with oxygen using mono and bimetallic catalysts based on Au, Pd and Pt metals

Of the three titles listed, which one is too general? Which one gives very specific information?

Activity 42

Agree or disagree to the following statements.

- A *declarative title* that clearly indicates the conclusion of a work is highly appreciable. *For example*, "Herbivore-infested plants selectively attract parasitoids."

- An *Inindicative title* that state what the study is about, but do not give the key conclusion are more preferred than *declarative titles*. For example, "Kinetics and Growth Mechanism of Electrodeposited Palladium Nanocrystallites"
- A title has to be written as a *sentence title*. For example: Herbivore-infested plants selectively attract parasitoids.
- A title may appear best if written as a *hanging title.* A colon or dash joins parts of the title. For example, TiCI, TiH and TiH^+ bond energies: a test of a correlation-consistent Ti basis set.

Declarative title vs indicative title

A journal may allow a *declarative title:* this gives the key conclusion of the study. However, *indicative title* may be considered scientifically more acceptable because the readers' own conclusions as to the significance of the work will not have been preempted.

Some journals do not allow a title to be a *sentence* (i.e. there must not be a verb).

Hanging title is a useful way of avoiding a long, grammatically difficult title. Either the first or the second part of the title can be used to describe the overall area; the other part gives more specific material.

Some journals allow *a question as a title*. The use of *questions* in the title, for example, "Does the southern dominance of solar activity really exist in solar cycle 21?" Questions can also be used as the second part of a *hanging title*. Example, "Replenishment of populations of Caribbean reef fishes: are spatial patterns of recruitment consistent through time?"

Series titles: Some journal editors do not like *series titles*. If the various papers appear in different journals, there are problems with the timing of publication, with the result that papers can get out of sequence. However, they are still sometimes used. A series of Journal article are number using roman numerals such as Title of the article followed by roman numerals like I, II, …

Abbreviations in the main title: Any abbreviations that one uses should be **widely known** in chemistry. You should refer the list of the abbreviations the journal may accept from *information to authors* of the Journal.

Checklist for the title

The following checklist can be used to evaluate a title and to make the required corrections to improve its writing quality

- Does it give the reader immediate access to the main point of your work?
- Does it adequately describe the significant features of your document?
- Does it use the fewest possible words and still make sense?
- Is it too long?
- Is it too general?
- Is it too detailed?
- Does it make sense?

The title page

This is usually the covering page (first page) of a longer document, giving the title and information about yourself and your institution, and any declaration that you may need to make. The title page should make a pleasing arrangement, with plenty of white space. The title page is not applicable for Journal articles.

The title page is cover page for your Student Research Project report that you may submit for graduation.

How to write the title page (cover page):

It should in general state:

- ✓ The title of your document
- ✓ Your name and department, university or institution
- ✓ The Logo of Jimma University
- ✓ The name of your advisor(s)
- ✓ The date of submission
- ✓ The name of the relevant person, organization or tertiary level course to which it is being submitted.
- ✓ The degree for which the thesis or report is being submitted and the institution. (A Research Report submitted to Department of Chemistry, Jimma University, in partial fulfillment of the requirements for the degree of B.Sc. in Chemistry).

Authorship and/affiliation (particularly in a journal paper)

Activity 43

Dear learner, reflect you views for the following questions.

A) What is the purpose of writing authors name on a journal article?

B) Who should be an author of an article? (The student who did a research? The lab technician who assisted the student? The instructor who guided the student? Department head that helped the student by providing necessary resources? Or college dean who approved funding for the research work?

Definition

Dear learner, in a real sense, authorship can be defined as the listing of authors only those who actively contributed to the overall design and execution of the experiments. Further, the authors should normally be cited in order of importance to the experiments, the first author being acknowledged as the senior author, the second author being the primary associate, the third author possibly being equivalent to the second but more likely having a lesser involvement with the work reported.

Thus, an author of a paper should be defined as one who takes intellectual responsibility for the research results being reported.

The purpose of writing the author(s) name on a journal article is to show the people who did the work presented in the paper, the institutions where it was done and, if necessary, the present addresses of the authors. Credit of authorship carries assumption of responsibility for and accountability of the work being published**.** Therefore, an author:

- Has made an original contribution to the article
- Can defend the main thesis of the article
- Have made a substantial contribution
- Approve of the paper's contents (read and agree)

- Take responsibility of at least part of the paper's contents

However, an author may not:

- Understand all of the details involved in generating the results
- Have spent a lot of time on it

Other contributors should be noted in the "Acknowledgements" section

How to write it

The journal's Instructions to Authors will define how to present the author and their affiliation information. In most chemistry journals, the title (Dr., Mr., Mrs.,) of the authors usually do not appear in the articles. An author should use always the same name (as a signature) to avoid any confusion within the scientific community. A "reliable name" is advisable. The corresponding author who is responsible to communicate with the editor of the journal throughout the publication process of the article can be indicated with symbol *. The complete name of the authors and address of the institutions or centers the authors belong to should be given. Currently e-mails are also given for further communication with authors.

Difficulties in resolving issue of authorship claims

There are two delicate aspects here, either of which can lead to misunderstandings if not handled well.

1 The name(s) that should appear on the manuscript, and the order of the authors (*Prestige).*

1. *The authors name order in a list (prestige)*: In the eyes of the scientific and technological community, the authors of a paper become identified with its work. A paper is very rarely known by its title; it is always referred to- in conversation as well as in texts - by the surnames of its authors, or as 'Smith *et al.',* if there are several authors. The quality and number of papers a person has published are the major determiners of respect in this community.

   The order in which the names should appear:

Author sensitivities When a paper has several authors, the order in which they appear under the title is very important. The sensitivities of authors run high. But there are no ground rules for deciding the order, and arguments are by no means unknown among co-authors for each one's place in the hierarchy. A neutral way of approaching this issue is to place all authors after the first author in alphabetical order.

First name position The first name carries the most prestige. This is the person who has written the paper, and who has generally done most or all of the work. As a graduate student, you are likely to take this first position with your supervisor(s) succeeding you.

Group leader or senior professor If there are a number of authors, one of whom is being included because of his or her rank in the organization and who may not have been very directly connected with the progressing of the work - this person's name is often included as the last author.

2. *The anxiety to be included:* People can often, therefore, be eager to be included as one of a paper's authors. This can lead to uneasy relationships, if you feel that their contribution doesn't merit inclusion in a paper where you think you have done all or most of the main work.

   Why people are so eager to be included as one of the authors of an article even if they do not have significant contribution?

   There may be several reasons, but the primary one could be *"the publish or perish"* syndrome. The inclusion of an author might result in promotion and try to get momentary advantages. Such trends should not be encouraged and only those who really have made significant contribution need to be included in the authors list.

3. *Author or acknowledged?* A difficult problem can be to decide whether to include a person as an author or whether instead to mention him or her in an Acknowledgements section. *Sole or co-authorship?* Some universities and departments state that supervisors must appear as co-authors. Others will allow the graduate student to be sole author. This must be resolved with your supervisor and guidelines for authorship of the institution. You should also discuss whether other people, such as other staff members, students or technical staff should also be co-authors.

 Self test exercise

Agree or disagree to the following sentences.

1. When all individuals in the laboratory claim an authorship for research results reported, they can get the requested right.
2. The head of laboratory where research activities conducted can claim for authorship.
3. The influential contributor can be at the first or last order for reported research results.
4. Only one or two authors should appear on a reported research findings.
5. Good scientists do not allow dilution of their own work by adding other people's names for their minuscule contributions, nor do they want their own names sullied by addition of the names of a whole herd of lightweights.

Abstract/Summary/Executive Summary

The Abstract or Summary is important for the understanding of the whole document. It has to be written very concisely and should provide adequate information. The following are the basic features of abstract section of an article:

1. Generally research reports are voluminous and hence these require time and energy to go through them. An abstract provides the awareness of the research work at a glance. It facilitates the readers and other research works to comprehend it easily and quickly.
2. The experts or examiners make use of the abstract in evaluating research papers. It communicates the work done by researcher and reviews some of the aspects wherever they require further clarifications. The abstracts are used by other researchers of the field to review the studies conducted in this area. It is an economical device for reviewing the related studies.

Journal paper Abstract Effective abstracts have become crucial in a journal paper, since they may be distributed electronically. Abstracting services are used by people to obtain the main points of your work, and to decide whether they need to read the whole of your paper. If the Abstract is weak, your work won't get the advertising that it may deserve.

Conference Abstract. Conference organizers will decide from your conference abstract whether to invite you to present a paper.\

Activity 44

In technical documentation the words Abstract and Summary are often used interchangeably to mean the same thing. Are they really the same? Do they have any specific difference?

The specific differences between Abstract and Summary are given below:

a) An *Abstract* presents the overview to an expert audience. It is required in specialized documents such as journal papers, conference papers and posters.

b) *A Summary* presents the overview to a less specialized audience. Anyone reading it should be able to gain an understanding of the main features and findings of your document, without the detail. It is required at the beginning of every document you write, if an Abstract or Executive Summary is not specifically asked for.

c) An *Executive Summary* presents the overview to an executive audience in non-specialist language. It is generally longer than a Summary, possibly a tenth of the whole document. It should present the work in greater detail than a standard Summary does. It is required in a management or consulting document, specifically for the management personnel of an organization. They may have no scientific or technical expertise. The language therefore needs to be understood by non-experts.

Activity 45

What is the relevance of an abstract?

Do you think writing the abstract section to be easy?

How a journal article can be summarized by an abstract not exceeding 250 words?

How do you select the important points to be included in an abstract and exclude others not to be included in the abstract? What are the selection criteria?

How to write Abstract or Summary: general information

1 The elements of information needed- probably in this order- are:

(a) Write a *statement that places your work in context.* This is a statement that presents the big picture. But avoid an overall statement of generally known fact.

From which section of IMRAD can you extract this statement?

(b) A brief and concise description of the *method of investigation employed.*

This might be a description of an experimental technique, an analytical method, a design technique, a system design etc.

From which section of IMRAD can you extract the statements?

(c) *Your main results or observations.*

This could be an experimental finding, a theoretical result, an improved design or system

From which section of IMRAD can you extract?

(d) *Your main conclusion(s).* Your deduction about what your work means.

An Abstract/Summary should contain only one or two main conclusions; the complete set of conclusions is then presented in a Conclusions section

(e) *Your main recommendation(s).*

If you have several recommendations, use a section called Recommendations.

Important tips: The Dos/Don'ts in writing an abstract

- √ An Abstract/Summary should not contain any information that does not appear in the main body of the document.
- √ Don't use tables, figures, or literature references in an Abstract/Summary. However, they are needed in a conference abstract of the longer type and if appropriate in an Executive Summary.
- √ Write the final version of the Abstract/Summary after you have completed the paper. If you write it early in the process to focus your thoughts, revise it later.
- √ It is vital to get the same emphasis and perspective as in the main body of the paper.
- √ Do not refer to any figures or cite any references in an abstract
- √ Predict the information that a reader doing a database search would like to find in the abstract.

Keywords

Keywords are the words that are used to reveal the internal structure of an author's reasoning. These are what people use when searching for articles in literature indexes. Some will be quite specific to your topic (such as the animals or plants you worked on or the particular conservation approach you took). Keywords should not be as broad as "ecology" or "conservation". When selecting keywords, imagine you are searching for your article in some database. The keywords should contain between five and eight words.

Why are they important?

Keywords are important as they can be used successfully in conjunction with the search engines to provide you with a free source of targeted traffic to your web site. They enable people who need your product, service or information to find you. Appropriate keywords are like a telephone number for your business and the search engine is like the telephone book – it lists your name and number.

Check list

Which of the following can you do? Write a tick mark (_) in the boxes provided if you can answer 'yes'. If not, revise the materials in this section once again.

Do you know why a scientific paper has a rigid format?----------

Can you list some features of excellent scientific titles?---------- ----------

Can you mention the main components that should a good scientific abstract contain?-

Conclusions

Purpose

The purpose of writing the conclusion section is to summarize the main points of the document, probably stated in the Discussion section. A Conclusion section is required by some journals. This serves the purpose of rounding off the document and summing up your conclusions and opinions. A person in a hurry should be able to read the Title, Summary/Abstract, Conclusions

and Recommendations of a document and obtain a complete but un-detailed overview of the document.

How to write conclusion section of a journal article?

- Each conclusion must be based on material that has already been presented in the main body of the report.
- Each conclusion should be related to specific material.
- Each conclusion should be brief (since the full explanation is given elsewhere in the document).
- The Conclusions section not only reviews the results or observations- it also interprets them. In this section, as in the Discussion, you can therefore point out:
    - what is important and significant?
    - why the results or observations are valid?
    - any criticisms or qualifications you may have of your own work

Start with your main conclusion and then present them in descending order.

Checklist for the conclusions

- Is there any material in the Conclusions that does not appear elsewhere in the document? If so, go back and incorporate it.
- Is there a sound basis for each of your conclusions?
- Is your first conclusion your main one?
- Are the other conclusions given in descending order?
- If necessary, do you point out the importance, significance, validity, criticisms or qualifications of your work?

Recommendations

To purpose of writing the recommendations in a scientific report is to propose a series of recommendations for action as a result of the conclusions drawn from your work (e.g. a design improvement, management strategies etc.). In a formal technical document, the section Recommendations is usually placed either at the start of the document, immediately after the

Summary, or at the end of the document. In this case it can often be usefully combined with the Conclusions into a section called Conclusions and Recommendations. In most journal articles, there is no separate section for recommendations. The main recommendations suggested are included in the last section of the conclusions.

Note that:

- Recommendations are your subjective opinions about the required course of action. But this doesn't mean you can go into wild flights of fancy.
- Recommendations can be of various types. Their character will depend on the purpose of your report, (e.g. to choose a new procedure or technique, and show why it is preferable, to identify a need, and suggest a way to fill it, to explore a new concept, and show how it should be applied to existing problems, to propose a new project and show why and how it should be carried out, to analyse a problem, find a solution and propose a remedy.)
- Recommendations are usually best given as a numbered list. Each item should be brief.
- Make the main solution to the problem your first recommendation. This usually fulfils the purpose of the report. Then list your other recommendations in a logical way. No recommendation should come out of the blue. The supporting information should exist elsewhere in the document.

Acknowledgements

This is an optional section. In this section the authors will have a chance to acknowledge (thank) people who directly contributed to the paper, by providing data, assisting with some part of the analysis, proofreading, typing, etc. You should also acknowledge the source of special equipment, cultures, or other materials as well as outside financial assistance (grants, contracts or fellowship). It is not a dedication section, so don't thank Mom and Dad for bringing you into the world, or your roommate for making your coffee.

References

Dear learner! Can you list some of the reference materials that can assist in scientific paper writing?

Diverse array of Reference materials are used to write a scientific paper. These include: Books, Journals, Accepted paper for publication, Theses (MSc or Doctoral), Encyclopedia, Personal communications, Lecture notes/technical repots (FAO/WHO), Web Sites and Unpublished data.

What are References?

Scientific progress requires building on existing knowledge, and previous findings are recognized by directly citing them in any new work. The citations are collected in one list, commonly called “References.” The reference list may seem like something you don’t actually read, but in fact, it can provide a wealth of information about whether the authors are citing the most recent work in their field or whether they are biased in their citations towards certain institutions or authors. In addition, the reference section provides readers of the article with more information about the particular research topic discussed.

In this references section, only publications that you cited in the report (if none, omit the section) are listed. Provide sufficient detail to enable somebody to actually track down the information. List all authors for the "*et al*." publications in the Reference list. Follow a standard format, and note the distinctions regarding italics, capitalization, volume/page numbers, publisher address, etc. between the various kinds of references.

Citation of references in the body

Dear learner, although there are an almost infinite variety of reference styles, most journals cite references in one of the three general ways that may be referred to as 1) name and year system, 2) alphabet-number system and 3) citation order system.

1. Name and Year System

The name and year system (often referred to as the Harvard system) has been very popular for many years and is used in many journals and books.

Activity 46

Can you mention some of the advantages of Harvard system?

The big advantage of Harvard system is its convenience to the author. First, because the references are unnumbered, references can be added or deleted easily. Second, No matter how many times the reference list is modified, "Smith and Jones (1990)" remains exactly that. If there are two or more "Smith and Jones (1990)" references, the problem is easily handled by listing the first as "Smith and Jones (1990a)," the second as "Smith and Jones (1990b)," etc.

Activity 47

What are some disadvantages of Name and Year System? Some disadvantages of Name and Year System

Distraction to the reader

The disadvantage to the reader occurs when (often in the Introduction) a large number of references are cited within one sentence or paragraph.

Example: The main general advantages derived from shade trees are well documented (Perfecto *et al*., 1996; Baggio *et al*., 1997; Beer *et al*., 1998, 1998; Negash, 1998; Muschler, 2001). These lengthy cited together references create inconvenience to a reader. As a result, sometimes the reader must jump over several lines of parenthetical references before he or she can again pick up the text. Even two or three references, cited together, can be distracting to the reader.

Increased cost to the publisher

The disadvantage to the publisher is obvious: increased cost. When "Smith, Jones and David (1990)" can be converted to numbering system say "(9)," composition, (typesetting) and printing costs can be reduced.

2. Alphabet-Number System

This system, citation by number from an alphabetized list of references, is a modification of the name and year system. Citation by numbers keeps expenses within bounds; the alphabetized list, particularly if it is a long list, is relatively easy for authors to prepare and readers (especially librarians) to use. Some authors who have habitually used name and year tend to dislike the alphabet-number system, claiming that citation of numbers cheats readers. As you cite references in the text, decide whether names or dates are important. If they are not (as is usually the case), use only the reference number. "Plant metabolites have antimicrobial potentials (13)." If you want to feature the name of the author, do it within the context of the sentence:" The role of the carotid sinus in the regulation of respiration was discovered by Heymans (13)." If you want to feature the date, you can also do that within the sentence:"Streptomycin was first used in the treatment of tuberculosis in 1945 (13)."

3. Citation order system

The citation order system is simply a system of citing the references (by number) in the order that they appear in the paper (this the recommended style for ACS Journals and the style is also adopted by Chemistry Department of Jimma University). This system avoids the substantial print expense of the name and year system, readers often like it because they can quickly refer to the references if they so desire in one-two three order as they come to them in the text. The main disadvantage of the citation order system for authors is the substantial renumbering chore that results from addition or deletion of references. This problem can be easily handled by using reference management software systems such as *endnote* and *procite*. Depending the reference insertion style of the journal, the numbers can be indicated in [ ], or ( ) or can be indicated as superscript.

Different rephrasing/citation styles in the text (Name and year system)

Some authors get into the habit of putting all citations at the end of sentences. This is wrong. In principle, the references should be placed at that point in the sentence to which it applies.

1) According to David (1990)/David et al. (1990) …
2) Mogessie *et al*. (2002) have demonstrated that…
3) Several studies (Tort, 1992; Tola and Granhall, 2007; Abbaha, 2008) reveal that…
4) Ethiopia is rich in genetic diversity of wild Arabica coffee populations (Aga *et al*.,2003; Daniel *et al*., 2006).
5) In a field trials, Amsalu and Hordofa (2005) reported that….
6) A growing bodies of evidence (Tola and Granhall, 2007; Abbaha, 2008) revealed that…

Different rephrasing/citation styles in the text (Citation Order system)

1) According to David (1)/David *et al*. (1)…
2) Mogessie *et al*. [2] have demonstrated that…
3) Several studies[3-5] reveal that…
4) Ethiopia is rich in genetic diversity of wild Arabica coffee populations [6-7].
5) In a field trials, Amsalu and Hordofa[8] reported that….
6) A growing bodies of evidence (4-5)…

I. Citation in the body-published data

1. Single author

Within the text, cite references by author (surname) and year unless instructed otherwise, for example "Comrie (1999) stated that ..." or "several studies have found that x is greater than y (Comrie, 1999; Smith, 1999)."

2 .Two authors

For two authors, list both names (second names)

For example "Comrie and Smith (1999)---

3. For three authors

For three or more use the abbreviation "*et al*." (note the period) following the first author name, "Comrie *et al*. (1999).“

X is greater than y (David *et al*., 2008; Tadesse *et al*., 2009).

II. Citation in the body-Web sites

a) By author(s)

---(Hussien, 2008)/…(Daniel and Armour, 2007)/….(Tom *et al*., 2006).

b) Anonym

....(web site).

e.g, …(http://ia.juniata.edu/citation/apa/apa00.htm).

III. Citation in the body-unpublished data

Single author: e.g. ….(Muleta unpubl.).

Two authors: e.g….(Roos and Granhall unpubl.).

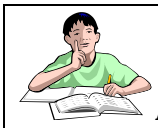
> Three authors: e.g….(Muleta *et al*., unpubl.).

Not included in the reference list!!!!

IV. Citation in the body-personal communication

Example: Rhizobium spp are inhibited by acidic soils (U. Granhall, pers. Comm. 2009).

Not included in the reference list!!!!



Activity 48

What is the maximum number of authors to use the Latin phrase *et al.* in body citation?

References Listing

Journals vary considerably in their style of handling references. For instance, one person looked at 52 scientific journals and found 33 different styles for listing references. You should list only significant, published references. References to unpublished data, abstracts, theses, and other secondary materials should not clutter up the References or Literature Cited Section. Check all parts of every reference against the original publication before the manuscript is submitted and perhaps again at the galley proof stage.

When you submit a manuscript for publication, make sure that the references are presented according to the **Instructions to Authors**. If the references are radically different, the editor and referees may develop negative attitude and ultimately leads to rejection of your work. There are computer software programmes that can automatically format bibliographies to a variety of specifications. Use ***Endnote***, or Xoterra, or Mendeley, reference software to format references for different journals (Science, Nature, etc). Basically, at the touch of a key, an entire bibliography can be formatted in a particular style. In addition, *EndNote* can reformat the text citations as well as the literature cited section at the end. Among the advantages of maintaining references in ***EndNote,*** References Manager, or similar systems is the resulting accuracy. Once a reference is entered correctly, there is no need to type it again. The following examples of references listing depends on **Name and Year System.**

A. Books

Author(s) last name, first and/or middle name initial, Year of publication. Title of the book. Publisher, place of publication. See the following examples carefully:

• Strange, R.N. 1993. *Plant Disease Control: Towards Environmentally Acceptable Methods*. Chapman and Hall, New York.

• Smith, S.E., and Read, D.J. 1997. *Mycorrhizal Symbiosis*. Academic Press, London.

B. Books (by contributors)

Author(s) last name, first and/or middle name initial, Year of publication. Title of the contributed chapter. Title of the book. Editor(s). Publisher, place of publication, page number of the chapter from which the information is taken or extracted. See the following examples carefully:

• van der Vossen, H.A.H. 2001. Agronomy I: Coffee breeding practices. In:*Coffee Recent Development*. Clarke, R.J. & Vitzthum, O.G. (eds.). Blackwell Science Ltd, London, pp.184–201.

• Azcon-Aguilar, C. & Barea, J.M. 1992. Interactions between mycorrhizal fungi and other rhizosphere micro-organisms. In: *Mycorrhizal Functioning: An Integrative Plant–Fungal Process*. Allen, M.J., (ed.). Chapman & Hall, New York, pp. 163-198.

C. Journals

Author(s) last name, first and/or middle name initial, Year of publication. Title of the Article Name of the journal. Volume number, Issue number (optional), page number of the article from which the information is taken or extracted. See the following examples carefully:

• Muleta, D., Assefa, F. , Hjort, K., Roos, S. and Granhall, U.2009. Characterization of rhizobacteria isolated from wild *Coffea arabica* L. *Engineering in Life Sciences* 9: 100-108.

• Albertin, A., and Nair, P.K.R. 2004. Farmers' perspectives on the role of shade trees in coffee production systems: an assessment from the Nicoya Peninsula, Costa Rica. *Human Ecology* 32: 443-463.

D. Accepted paper for publication

Author(s) last name, first and/or middle name initial, Possible year of publication. Title of the Article. Name of the journal. Write the phrase "in press". See the following examples carefully:

Muleta, D., Assefa, F. , Hjort, K., Roos, S. and Granhall, U.2009. Characterization of rhizobacteria isolated from wild *Coffea arabica* L. *Engineering in Life Sciences* " *In press*"

Although journal styles vary widely, one aspect of reference citation has been standardized in recent years, i.e., journal abbreviations. *Journals name shall be abbreviated according to Chemical Abstracts Service Source Index (CASSI).* The *CASSI* abbreviations are used to refer to journal names in reference lists (See *The ACS Style Guide* for *CASSI* abbreviations)

Example

Sample journal-title abbreviations according to *CASSI*

Acc. Chem. Res.	*Chem. Res. Toxicol.*	*J. Phys. Chem. A*
AIChE J.	*Environ. Sci. Technol.*	*Langmuir*
Anal. Chem.	*Inorg. Chem.*	*Nano Lett.*
Biochemistry	*J. Agric. Food Chem.*	*Nature*
Biochem. J.	*J. Am. Chem. Soc.*	*Org. Lett.*
Can. J. Chem.	*J. Org. Chem.*	*Science*

D. Theses (MSc and Doctoral)

Author last name, first and/or middle name initial, Year of publication. Title of the Thesis from which the information is taken or extracted. MSc/Doctoral Thesis, the name of the degree offering University, city where the work is done, name of the country. See the following examples carefully:

- Polzot, C.L., 2004. Carbon Storage in Coffee Agroecosystems of Southern Costa Rica: Potential Applications for the Clean Development Mechanism. M.Sc. Thesis, York University, Toronto, Canada.
- Muleta, D. 2007. Microbial Inputs in Coffee Production Systems, Southwestern Ethiopia: Implication for Biofertilizers and Biocontrol Agents. Doctoral Thesis, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden.

E. Technical report/government

- Comrie, A.C., 1999. The climate of Tucson. Report ABC-001, Institute for Climate Studies, University of Arizona.
- Taye, E., 2001. Report on Woody Plant Inventory of Yayu National Forestry Priority Area. IBCR/GTZ, Addis Ababa, Ethiopia.
- FAO, 1968. Coffee Mission to Ethiopia 1964–1965. FAO, Rome.

In the References section, some journals prefer that all authors be listed (no matter how many); other journals cite only the first three or four or five or six authors and follow with Latin phrase "et al."

Example1: Daba, A.S., Kabeil S.S., William A., Botros, El- saadi M.A. 2008. Production of mushroom (*Pleurotus ostreatus*) in Egypt as source of nutritional and medicinal food. World J.Agric. Soc 4:630 – 634 **(All authors listed)**

Example *2*: Daba A.S., Kabeil S.S., William *et al*. 2008. Production of mushroom (*Pleurotus ostreatus*) in Egypt as source of nutritional and medicinal food. World J.Agric. Soc 4:630 – 634. **(The first three authors listed).**

F. Web sites

- Biotechnology and Sustainable agriculture: Biofertilizers and Biopesticides. 2004 Pugwash Workshop, Cuba. http://www.pugwash.org/reports/ees/cuba2004/02%20Pugwash/07_Ondina.pdf; pp.1-33 (accessed 21-Aug-2007).
- Brooth, A.G. Applications of microorganisms in biotechnology. http://ia.juniata.edu/citation/apa/apa00.htm; pp1-27 (accessed 22-June-2007).

Remarks

_ This section lists only all articles or books cited in your report. It is not the same as a bibliography, which simply lists references regardless of whether they were cited in the paper or not.

_ The listing should be alphabetized by the last names of the authors. However, different journals require different formats for citing literature (over 200 styles are there).

_Only use references pertinent to your study and your data

_ If author/authors has/have more than two articles in the same year, use a, b, c…

e.g. **In the body**: …. (Young *et al*., 2005a; 2005b).

In the references list: Young, A.M, Yan, K.T, and Tortof, R.E. 2005a…

Young, A.M, Yan, K.T, and Tortof, R.E. 2005b…

4.2.1.6 **Appendices**

This section is optional and applicable mainly to Theses (MSc and/or Doctoral) but quite uncommon in published articles. If necessary, one or more appendices containing raw data, figures not used in the body of the paper, sample calculations, etc. may be included. They are considered as additional material to the report, and may not be examined by the reader at all.

Important!

☞ Always read published data (articles) and imitate when you intend to write a scientific paper!

☞ Read and understand closely every component of an article.

☞ ***Be consistent in your writing!***

☞ Above all, produce accurate, clear and concise scientific paper!

Check list

Dear learner, in the previous subsection you dealt with and described properly a range of scientific paper components. Thus, which of the following can you do? Write a tick mark (√) in the boxes provided if you can answer 'yes'. If you cannot, put an 'x' and go back to revise once more the subsection in order to master the topic covered.

1. Can you list all the components of the scientific paper? ..... □
2. Can you describe properly each component of scientific paper? ..... □
3. Do you know the reasons why a scientific paper has a rigid format? ..... □
4. Do you know who will be author(s) for a particular conducted research work? ..... □
5. Do you know whom to acknowledge in your scientific paper? ..... □
6. Can you mention different ways of citation of references in the body? ..... □
7. Can you list some of the advantages of using Harvard system for citation of reference in the body? ..... □
8. Can you tell the difference between Name and Year system and Alphabet-number system? ..... □

Activity 49

Select a topic on any chemistry topic (synthesis of organic or inorganic compounds, analysis of important analyte in environment, characterization of the phyisico chemical property a given matter, etc) Go to a nearby library and try to get different books, journals, Theses (if any), technical reports (if any) or any relevant source of scientific information. Take pertinent information from the surveyed materials. Then a) Show your citation in the body using Citation order system b) list the referred literature in the References list following the Citation order system.

4.3 **Oral Presentation**

Talk low, talk slow and do not say too much

-John Wayne

Dear learner, the quality of presentations in scientific meetings often leaves much to be desired. A number of sources are now available to help researchers improve their presentations. A good scientific presentation must follow the following three "Ps". It should be: Planned with care, Prepared with care and Presented with care. The following sections provide some useful guidelines, particularly for beginners.

Although this document applies to all, it has been written from the perspective of you distance students who generally have been less exposed to some of these ideas than others who have learned from experience. You'll find that these skills will be invaluable whether you pursue an academic, government or industrial career in both the applied and theoretical sciences. Just remember that these guidelines are intended to assist you in developing a workable style of your own. Read, think, experiment and then adopt those elements that work for you and your audience.

1. Planning of the presentation

In planning a scientific presentation, presenters need to ask the organizers of the scientific meeting about: the audience and their level of knowledge and interest in the subject since the planning of the presentation will be different for a specialist audience, a generalist audience or a

mixed audience; the time available for the presentation; and the type of visual aids available. Presenters should ask themselves what the main message (or messages) is that they would like to convey and how it can be conveyed to the type of audience concerned in the time allotted. Extensive citation of the literature is undesirable in an oral presentation. To change a written scientific paper into an oral presentation, the presenter must follow three "s words": Select, Synthesize, and Simplify. Select from the written article the points to present. Synthesize the information in the article to package it in the limited time available. Simplify the presentation of the data, so that it can be easily followed and understood by the audience.

2. Preparation

Preparation of text

In preparing the text of a scientific presentation:

• Avoid too much detail and resist the temptation to overload the presentation with information.

• Avoid jargon and abbreviations, unless they are clear to all the audience.

• Aim at the average person in the audience.

• Use plain English.

The structure of a presentation is different from the structure of a written paper.

Normally, it should consist of three parts: introduction, main message and conclusions. The introduction should tell the audience what the presentation will be about. Where possible, the opening sentences should capture the attention of the audience. It helps to have something like a "punch line", which will alert the audience to the importance of the subject. The main message should be clear and concise. The usual detail of a written paper is unsuitable for a presentation. It is generally unwise to introduce more than one new idea every 2 to 3 minutes. The conclusion should summarize the main points. Try for a strong finish. Stopping speaking is not finishing. Leave the audience with a "take home message".

Preparation space

Space to prepare a presentation should be peace and quiet. Key distractions include: the telephone, e-mail, co-workers and the boss!

Font size

As a general rule, no slide should be shown unless it can be read by the back row of the audience (use large enough font). Generally, for power point presentation, use something greater than 24 point font but depends on number of audience. Normally, use 24-36 point font for *texts* and 40-48 for *headings* with font style Helvetica or Times New Roman or Arial. Use boldface. Use italics and underlining for emphasis, but avoid using many different font styles on the same visual. Also, don't use a font that is too complex. Upper case letters are less legible than lower case letters. This is why lower case is commonly used in direction signs on motorways and on the underground. Our eyes are more accustomed to small letters in books and newspapers. Use of scientific names Italicize/underline Latin genus and species names. Be certain to put the initial letter of genus name in upper case and that of species in lower case. For example: *Homo sapiens* (Computer) and Homo sapiens (Type writer/handwritten).

Use Color Effectively

The use of color can enhance a presentation, particularly when used in moderation in the figures and diagrams. Only use high contrast color combinations. While choice of colour is a matter of test and judgment to a certain extent, colour should not be used for decoration but to improve understanding. Select colours that project well. Popular combinations are blue and white, and black on white. It is advisable not to use dark backgrounds. Choose a single background for the entire presentation. Colors such as yellow and some greens and pinks do not show up well on overheads. The number of colours should be limited to what is really necessary for presenting the data in a clear way. What looks legible and attractive on a computer screen may look worse on the overheads. Make rehearsal on your presentation before the actual presentation, if possible with the same room and similar audiovisual material.

Preparation of visual aids: speaking visually

"Things seen are mightier than things heard." - Alfred Lord Tennyson

Bring something to show the audience, if possible. Be sure to add figures and photos to your slides, where appropriate. Digital photos are an easy way to share with the audience the physical arrangement of your experimental setup. Do not crowd material onto visual aids; keep them free of visual clutter/mess. Your visuals must be free of any

- ❖ Grammatical
- ❖ Typographic or
- ❖ Spelling errors

Purposes for using visual aids

It has been said that we remember 20% of what we hear, 30% of what we see, but between 50% and 75% of what we see and hear. A Chinese proverb says "A picture is worth a thousand words". Visual aids are not an objective in themselves. They are used to serve one or more of the following objectives:

- attracting and maintaining the interest and attention of audience
- presenting the data in a clear way
- delivering the presentation without having to read from notes.

Commonly used visual aids include chalkboard, whiteboard, flip charts, slides, overhead transparencies and computer assisted presentations. Overhead visuals must easily be read by people of many different ages and abilities to read and see. Large print and well-organized visual aids are particularly helpful for some audience with disabilities that affect their sight, learning, or hearing.

Slides

Title slide with author(s) name(s) and affiliation(s)

Slides are the commonest visual aid used in scientific presentations. They can make or break the presentation. Slides that are thoughtfully designed and well prepared can greatly enhance the value of a scientific presentation. Until recently photographic film slides were very commonly used; now electronic slides presented as a data show have largely taken over. The basic rules for a good presentation are the same for film slides and electronic slides. Slides prepared from graphs that were drawn for journal publication are seldom effective and often are not even legible. Slides prepared from a typewritten manuscript or from a printed journal or book are almost never effective. There are three main types of slide: text slides, data slides (tables, graphs, flow charts) and figure slides.

A mix of text, data and figure slides helps to maintain the interest of the audience.

Text slides are not meant to be read by the speaker, but by the audience. Lettering should generally be limited to 4 lines and should never be more than 7, including the title. It is advisable not to use more than 8 words per line.

Data slides

Complicated tables are not visual aids. They have been described as instruments of torture for the audience. Tables of data suitable for written publication are highly unsuitable for a scientific presentation. The term "Railway Timetable slides" is sometimes used to describe the difficulty with slides showing complicated tables. Do not use more than seven lines (including title) and four columns in any table. Graphs should replace tables where possible in a visual presentation. They are better in showing relationships. Preparation of graphs has now been made easy by computer programs.

Four types of graphs are often used: bar or column charts; curves; pie-charts; and scatter graphs.

• Bar charts are better for lettering than column charts. Avoid overcrowding the slide. The number of bars should be limited to five to seven. An overcrowded column chart is sometimes called a "New York Skyline" slide, to emphasize that it is not suitable for presentation.

• No more than two or three curves can be shown on a slide. Space on the slide should not be wasted.

• The slices of a pie-chart must not be too numerous nor too small. Three to five divisions are ideal.

• Scatter graphs are good for slide presentation. They give a clear and simple overview of the scatter of the data to show relationship.

• Flow charts should not be complicated. A complicated flow chart looking like a "subway" map is not useful for a presentation.

Figure slides of drawings and pictures, if meant for humor, should be selected with care and sensitivity to the type of audience. They should not offend the feelings of anyone in the audience. *When you write the slides, be certain that one logically leads into the next. Don't include slides with disconnected bits of information and images.*

Computer software

Computer software is used for preparation of electronic slides for a data show. A widely used program is Microsoft Powerpoint. The same program can make the preparation of 35-mm film slides easier and better. Computer generation of electronic or field slides offers a number of additional advantages. The software guides you through the preparation, provides templates and recommends consistent colour schemes. Preparation of graphs is easy. Photographs and drawings can be imported from other software programs. The program allows each slide to have a text note attached and the slide and note can be printed out on the same paper page to serve as speaker's notes. A number of slides can be printed out on one page of paper to be used as audience handouts. The slides created for a presentation can be viewed and edited on the computer screen. Slides are saved and can be included in another presentation. The slides created for a presentation can be viewed in a timed fashion on the screen and the timing of the accompanying talk can be checked and adjusted.

Power point is a fun program with many bells and whistles (animations, backgrounds, ability to layer text and images, etc.). Be creative, but do not include so many of these that it distracts your audience from your content. Thus, avoid too much animation.

Overhead transparencies

The overhead projector is a natural successor to the chalkboard. It is particularly useful in presentations to small groups. Overhead transparencies, as visual aids, have advantages and disadvantages.

Make Legible Transparencies

Use a computer to prepare your transparencies. If this is impossible, you must take great pains to ensure that your writing is legible. Make sure that the text is large enough to be read from a distance.

Don't Overload Transparencies

Don't put too much on each transparency. Try not to write full sentences. The transparency is an *adjunct* to your talk; it should be used for emphasis, to resolve ambiguity, for precision and for the retention of information over a short period of time. There should generally be no more than about six words per line and 10-12 lines per a transparency sheet/visual. Try to make all the points on a single slide relevant to a single specific point.

Don't Use Too Many Transparencies

The number of transparencies per talk will vary from person to person, and will depend upon the type of material being presented and the amount of text on each transparency. Plan an average of 1.5 to 2 minutes for each transparency (shorter for photos or simple drawings).

Avoid Slide Covering

Avoid situations where you want to show only part of a transparency. Make two transparencies instead.

Computer-assisted presentation

Computer-assisted presentation technology is rapidly becoming the standard for the use of visual aids. However, do not overuse the animation features as they can distract the audience and become annoying. A good presentation is also a simple presentation. Include no more than 3 or 4 bullets on a single slide. Before preparing a computerassisted presentation check about the availability of the equipment. Since the new technology is prone to equipment failure, it is advisable to have a backup of slides or overhead transparencies.

Activity 50

What are the main purposes of using visual aids?

Dear learner, it has been said that we remember 20% of what we hear, 30% of what we see, but between 50% and 75% of what we **see** and **hear**. A Chinese proverb says "A picture is worth a

thousand words". Visual aids are not an objective in themselves. They are used to serve one or more of the following objectives:

- Holding the attention of the audience
- Presenting the data in a clear way
- Delivering the presentation without having to read from notes.

Do not make your slides/transparency sheets garrulous. Visual aids (be overheads, slides, handouts, models, audio or video clips) must always be simple, clear and pertinent.

3. Rehearsal

The preparation of the text and of the slides has to take the allotted time into consideration. Rehearsal is the key to making sure that you will deliver the presentation without exceeding the time. Even very experienced speakers rehearse their presentations.

The practice must be verbal, not just mental. It does not have to be done in front of an audience. You can rehearse on your own, or with the help of colleagues. A pleasant average rate of delivery is not more than 120 words a minute. A double spaced typewritten page is about 240 words. For a ten minute presentation, plan on no more than five pages of double-spaced text. A general rule is one slide per minute if the slide contains information and one slide every 5-10 seconds if the slide contains only titles, key words, or is designed just to remove another visual from the screen. Having to skip slides during the presentation, because the slides are too many, means that preparation of the presentation was poor.

4. Mode of delivery/Presentation

The challenge to the speaker is to hold the attention of the audience. Particularly when the lights are dim, the audience can have sweet dreams during a boring presentation. This first section is possibly the most important part of your presentation. It sets the tone for the entire talk. Where possible, the opening sentences should capture the attention of the audience. First impressions are very important. The key steps to scientific paper presentation are:

•*Get ready*

• *Speak well*

• *Manage your slides*

• *Keep to the time*

• *Be prepared to answer questions.*

Getting ready

It is always advisable to check the room where the presentation will be given, in advance. Get to the hall ahead of the audience and walk up to the stage and look things over. Familiarize yourself with the Stage. Check the podium for the microphone, the remote control for the slide projection, the slide pointer and the lights. Try to understand also how do these materials work? Make sure that your slides are inserted in the proper order and in proper orientation. Provide your slides, properly arranged, or diskette to the technician for projection.

Speaking well

Perfection in speaking is acquired by practice, by observing good speakers, and by learning from your own mistakes as well as the mistakes of other speakers. If the microphone is to be attached, attach it to the lapel of the jacket or dress, and not to a movable part such as the necktie. It can produce a distracting background noise when you move. Look the audience in the eye. It is more effective not to read your presentation.

Pauses in speaking replace punctuation in writing: comma: break of one second; semicolon: break of two seconds; period/full stop: break of three seconds; paragraph: break of four seconds. Varying the tone, pitch and volume helps to maintain the attention of the audience.

Speak slowly and clearly

If you proceed too fast, especially at the t beginning, your audience will lose the thread, the daydreams will begin and your message will be lost.

Convey keenness, Excitement, Confidence

"Nothing great was ever achieved without enthusiasm" – Ralph Waldo Emerson Believe in what you are doing. Let the audience know that you have something very interesting to share with them. An enthusiastic speaker can bring life to an otherwise bland subject.

Use Humor

Although humor should not be a major focus in a scientific conference, it can play a very powerful role in keeping the audience's attention. Remember that your goal is to educate the audience, not simply to present material to those who care to listen. Humor and enthusiasm are useful techniques to reach this goal.

Maintain Eye Contact

Maintain eye contact with your audience. Spread your attention throughout the audience instead of concentrating on any one person or group (even if they are the only ones who matter). If presenting at a conference, be sure to glance periodically at the session chair, who will signal you when you are running out of time. Stand at 45o when you want to write on a white/black board.

Avoid reading slides text

You should never read the slide text to the audience; to do so would be an insult to your audience, unless you are addressing a group of illiterates.

Control Your Voice

Speak clearly and with sufficient volume. Don't speak in a monotone. Avoid utterances such as "Um, ah, er", etc. (This is a sure giveaway that you haven't practiced your talk). Avoid fashionable turns of phrase and hype.

Control Your Motion

Project energy and vitality without appearing hyperactive. Use natural gestures. Try not to remain rooted in one spot, but avoid excessive roaming. If you do manage to do something embarrassing, don't stop the presentation. Just keep going.

Take Care with Your Appearance

Good grooming and dress is important but avoid appearing overly ostentatious. Casual business dress is often the norm today for colloquia and conference presentations. A jacket and tie for men and professional attire for women is also common, particularly if an individual is interested in seeking employment in the near future.

Minimize Language Difficulties

English appears to be a common language for scientists of all nations. It is a good idea to get a native speaker to look over your transparencies before you deliver the talk. Use a prepared text, if necessary. Fluidity in your speech is quite important.

Don't Start Your Talk with an Apology

How often have you heard someone start with an apology such as "I really didn't have enough time to do my presentation . . .?" The speaker may be doing nothing more than trying to deal with his/her own nervousness, but as a result the audience now has a lower opinion and expectation of the speaker and their presentation.

Try Not to Get Anxious

For many people, speaking in front of a group is an occasion for sweaty palms and shaky voices. One study found that public speaking was second only to death as the most common fears. The best solution for nervousness is rehearsal (alone/to small/large groups) with adequate practice and preparation. Thereafter, confidence can be developed.

Be Different

Observe what successful presenters do that make their presentations so interesting. Some have a natural "theatrical" skill that many of us would never be able to imitate. Don't worry. Instead, focus on many of suggestions in this manual that anyone can master and see in their presentation. If you can master the structural issues, you'll soon find the confidence that seems to come so effortlessly to natural speakers.

Be Open about Problems

Be open about any uncertainties in your work. This way you may defuse antagonistic questions during question time. Stopping speaking is not finishing. Leave the audience with a "take home message".

Indicate that your Talk is over.

An acceptable way to do this is to say "Thank you. Are there any questions?"

Managing slides

Mark and number film slides. Check your slides before the presentation. Remember the saying that if anything can go wrong, it will. Be prepared for the possibility of breakdown of visual equipment. Do not read the slides. You can safely assume that the audience is literate and is not blind. Do not go back to a previous slide. Insert a copy. Focus on just the main points of one topic on a single visual. Make certain that you know what your topic is and tell it clearly.

Keeping to time

Most oral presentations are short (with a limit of 10 minutes at many meetings). A typical time allotted for symposium presentations is 20 minutes. A seminar is normally one hour. No matter how well organize, too many ideas too quickly presented will be confusing. You should stick to

your most important point or results and stress that. The speaker who exceeds his/her allotted time is guilty of gross bad manners. S/he imposes not only on her/ his audience, but also on all the speakers who come after him. It is a sign of poor preparation.

Activity 51

What are the three greatest obstacles that a presenting scientist faces? Write down your answers before advancing to the next paragraph.

The three greatest obstacles a presenting scientist faces embody: i) *fear*, ii) *an over-technical text-heavy presentation and iii) a less-knowledgeable-than-expected audience*. *Answering questions*

As we have already seen, it is customary to end a presentation with a short period for questions. You can expect to receive three types of question. The first is the genuine request for knowledge, which should cause you no difficulties if you are adequately prepared. The second is the selfish question, in which the questioner merely wishes to draw attention to him or herself and elicit wonder at his or her ability to devise such an insightful and rational question. It is polite to take a few seconds to compose a reply that directly or indirectly compliments the questioner. The third and most important category is the malicious question. The best defense against these types of questions is to be prepared. Answer politely: Do not answer questions in a rude or offensive manner.

Answer knowledgeably. Avoid getting involved in a lengthy exchange. Do not be afraid to answer “I don’t know” to some questions.

4.4 Poster Presentation

What is poster?

Posters are display boards on which scientists show their data and describe their experiments. Scientific posters are a good way to disseminate the results of a research project without having to give an oral presentation. Scientific posters are used at events such as professional scientific meetings (conferences), but can be found at junior high science fairs as well. They are of lesser importance than actual articles, but they can be a good introduction to a new piece of research before the paper is published. Poster presentations are often not peer-reviewed, but can instead be submitted, meaning that as many as can fit will be accepted.

Posters can be printed out on one large sheet of paper with a special printer or made of several smaller pieces of paper hung together. Regardless of where they are to be used or how they are constructed, scientific posters should all be constructed in the same format.

In recent years, poster displays have become ever more common at both national and international meetings.

Why a poster is usually better than a talk?

Although you could communicate all of the above via a 15-minute talk at the same meeting, presenting a poster allows you to more personally interact with the people who are interested in your research, and can reach people who might not be in your specific field of research. Posters are more efficient than a talk because they can be viewed even while you are off napping and especially desirable if you are terrible at giving talks. And once you have produced a poster, you can easily take it to other conferences. And when you're ready to retire your poster from active duty, you can hang it in your dorm room to impress your friends, or display it in your departmental hallway so that faculty can show off your hard work to visitors for years to come. You can also submit your final product to *ePoster.net*, which promises to keep a PDF version of your poster in eternity (for free) and allows people to send you comments about your poster.

Preparation

There is very little text in a well-designed poster, most of the space being used for illustrations. A poster should be self-explanatory, allowing different viewers to proceed at their own pace. *If the author should spend most of his or her time merely explaining the poster rather than responding to specific question, the poster is largely a failure.* Lots of white space throughout the poster is important. Distracting clutter will drive people off.

Unreserved effort should be made to make poster very clear what is meant to be looked at first, second, etc.(although many people will still read the poster backwards). It is a good idea to prepare handouts containing more detailed information for colleagues with similar specialties.

Layout

Organize your poster from left to right and top to bottom. One good method is to divide your material into 3 to 6 logical sections (Figure xxx). Layout each section as a vertical module on your poster, moving from left to right and leaving space between each module. Empty space is important and can be used to separate parts of your poster or establish relationships between modules or sections. Avoid clutter.

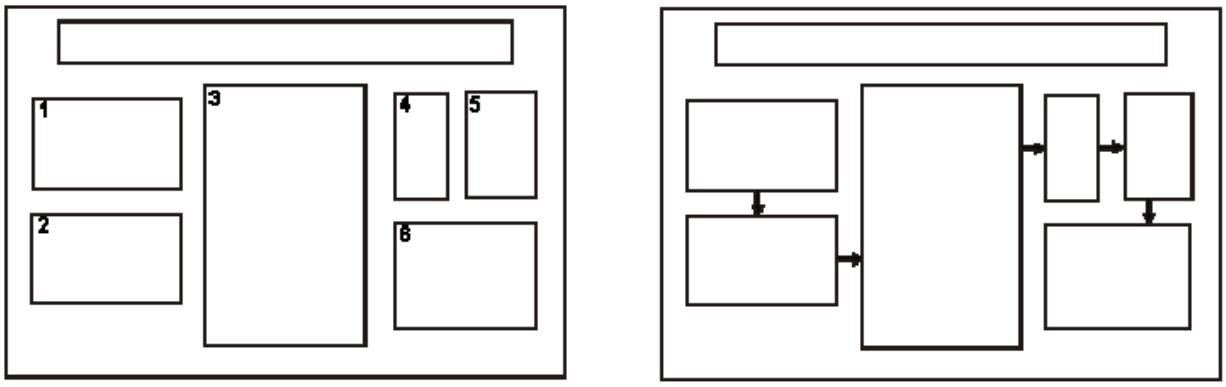


Figure 4.8 Conventional layouts for a poster. Long panel at top-center is title/author banner. Individual panels can be connected by numbers and arrows. Also, note the use of space between panels to achieve visual appeal.

Activity 52

A good scientific poster should address key points. What are the key-points that your research poster must cover? Discuss and write down your answers.

Your poster should cover the KEYPOINTS of your research. Thus ideal poster is designed to:

(1) Attract attention;

(2) Provide a brief overview of your work; and

(3) Initiate discussion.

Text length

The number one mistake is to make your poster too long. Densely packed, high word count posters are basically manuscripts pasted onto a wall, and attract only those viewers who are for some reason excited by manuscripts pasted onto walls. Posters with *800 words or less are ideal*. For those who feel that *their* experiment somehow warrants an exception to this brevity advice (i.e., "everyone"), find a friend to help you edit, asking them, "What text, figure, or table could I possibly delete or modify?" Avoid titles with colons. Titles with colons are, on average, longer than a normal title and so take longer to read. Avoid blocks of text longer than 10 sentences. Whenever possible, use lists of sentences rather than blocks of text.

Lettering, sizes and shapes

- Word-process all text (including captions). Print on plain white paper with a laser printer or inkjet printer.
- Text must be legible. The *title* should be legible from at least 5 meters and *text* from 1-2 meters.

Table 4.7 Recommended font sizes for a poster

Component	Font size range
Title	60-90
Heading	40-60
Subheading	50-30
Text	18-50

- Define all abbreviations the first time they appear in the poster.
- To maintain legibility avoid the use of ornate or script fonts. Blocky fonts like Swiss, Helvetica and Arial or conservative serif types like Times Roman and Bookman read well. In the body of the text, follow normal convention when employing italics and capital letters.
- Use *italics* instead of underlining.
- When using acronyms and numbers (e.g., ATP, 666) within the body of text, scale down the font size by a couple of points so that their sizes don't overpower the lowercase text, which they would do if you left them at the default size.
- Avoid formulas.

Indentation and line spacing

- Single space all typing; no space between title and body or between paragraphs.
- Do not trust the "tab" feature to insert the correct amount of space when you are indenting a paragraph (the default is usually too big). Set the tab amount manually, with the ruler.
- Correct any errors in spacing within and between words, especially before and after *italicized* text.
- Indent each paragraph with a tab space.

Visuals

Visual impact is particularly critical in a poster session. As with the rest of your poster, strive for brevity, simplicity, and clarity. If you lack graphic talent, consider getting the help of a graphic artist. The following are some important points related to visuals:

- Present numerical data in the form of graphs, rather than tables (graphs make trends in the data much more evident). Graphs with no more than three lines or six bars are preferable. Include captions and legends but keep them short and informative. Maintain a consistent labeling system for all graphs. When data of the same type are presented on separate graphs, it may be useful to use the same scale on all axes. If data must be presented in table-form, *KEEP IT SIMPLE*. Tables with more than 20 data cells will begin to overwhelm a typical viewer.
- Visuals should be simple and bold. Leave out or remove any unnecessary details.
- Make sure that any visual can "stand alone" (i. e., graph axes are properly labeled, maps have north arrows and distance scales, symbols are explained, etc.).
- Make sure that the text and the visuals are integrated. Figures should be numbered and referred consecutively according to the order in which they are first mentioned in the text. Each visual should have a *brief* title/caption (for example: Figure 1- Location of study area).

Colors

A poster should contain highlights, so that passers-by can easily discern whether the poster is something of interest to them. Choose a background that emphasizes the material you want to present. However, avoid using dark backgrounds. There are numerous reasons for this, but probably the most important is that dark backgrounds make designing graphics a *royal* pain. It's better to just use a light background. And you save on ink, too, so the media people won't put a hex on you. Consider the following remarks with regard to color utilization in your poster.

- Use color to enhance comprehension, not to decorate the poster. Neatly coloring black-line illustrations with color pencils is entirely acceptable.
- Use a light color background and dark color letters for contrast.

- Avoid dark backgrounds with light letters - very tiring to read.
- Stick to a theme of 2 or 3 colors - much more will overload and confuse viewers. If you use multiple colors, use them in a consistent pattern - otherwise viewers will spend their time wondering what the pattern is rather than reading your poster.
- Overly bright colors will attract attention - and then wear out readers' eyes.
- Consider people who have problems in differentiating colors (colour blindness), especially when designing graphics - one of the most common is an inability to tell green from red.
- Blues, browns, greens or grays are appropriate for framing.

Proper utility of logos

Institutional logos are great on departmental letterhead and college athletic caps, but are really rather obnoxious on posters. This is because your institution's name is *already* on the poster in the address below the title, and thus the logo adds absolutely nothing except recognizable branding. And because they are invariably nicely designed, logos always undermine the visual impact of the (important!) images of your research. For exactly the same reasons, please do not include your family's coat of arms, regardless of how prestigious a bloodline you think you come from. But if you are somehow genetically pre-dispositioned to use logos on your poster, make sure that they are small (1" for maximum dimension) and corralled into the Acknowledgement section along with, perhaps, logos of funding organizations. E.g., never, ever put a logo at the top of your poster.

Edition

- Edit all text to simplify verbiage, to reduce sentence complexity, and to delete details.
- If it's not relevant to your message, remove it!
- Have colleagues comment on drafts. Print a SMALL VERSION and circulate for comment, or hang a full-size draft with pens and invite them to critique.
- EVALUATE your work - try the 60 SECOND EVALUATION.
- Are your objective and main message obvious?
- Will readers be able to contact you?

Organization of a poster

Activity 53

What are the components of a scientific poster? List and describe each component properly.

All posters should be organized using the following format:

Title

Do not write an overlong title. Titles that use excess jargon are a bore. Titles with colons in them are also a bore. Titles that are too cute are even more of a bore. *Thus keep your title short, snappy, and on target*. The title needs to highlight your subject matter, but need not state all your conclusions, after all. Some good titles simply ask questions. Others answer them. Do not make the title type size too large or too small. Make your title large enough to be read easily from a considerable distance (say, 25-50 feet), so it will perforce span more than one printed page. Nevertheless, the title should never exceed the width of your poster area (particularly if you are sharing half a poster board with a neighbor!), nor should it ever occupy more than two lines. If things don't fit, *shorten the title*; don't reduce the type size. And remember that titles in all capital letters are harder to read. The typeface should be bold and black, and the type should be about 30mm high

Author (**s**) (upper-lower case letters)

Don’t leave people wondering about who did this work. Try to put the names of all authors and institutional affiliations just below (or next to) your title. It's a nice touch to supply first names rather than initials. Don't use the same large type size as you did for the title; use something smaller (perhaps 20mm) and more discreet. The text type should be about 4mm high (a type size of 24 points is suitable for text). Presenting author must be listed first (upper-case letters). For each author, include first and second initial and last name, and highest degree (one only). Separate author name from degree with comma; separate authors with semi-colon. Example: FC Jones, MD; AF Hill, PhD; KG Witherspoon, BS.

Affiliation(s)

List institution(s) where work was performed. Present affiliation information in a new line immediately following author line and include author initials following affiliation. Example: FC Jones, MD; AF Hill, PhD; KG Witherspoon, BS From the Morehouse School of Medicine (FCJ); New Way Out Ministries (AFH, KGW)

Abstract

A brief summary of the principal findings of the research conducted. Do not include an abstract on a poster! If you are presenting your poster at a meeting, you will probably be asked to *submit* an abstract; this abstract is for inclusion in the "meeting catalog," not for *on* your poster. If for some reason you are *forced* to include an Abstract section on your poster, please certainly abide by those rules, but consider asking the meeting organizer why on earth their society's guidelines are so silly. At the very least, don't make your abstract long: aim for 50 words or less.

Introduction

A clear statement of the problem or project and why you are studying it. The poster will fail unless it has a clear statement of purpose right at the beginning. Get your viewer *interested* about the issue or question while using the absolute minimum of background information and definitions (such things put a reader to sleep, which is really dangerous if he or she is standing); quickly place your issue in the context of published, primary literature; provide description and justification of general experimental approach, and hint at why your study organism is ideal for such research; give a clear hypothesis. Please note that "X has never been studied before" is a classic but classically lame reason for doing something. Unlike a manuscript, the introduction of a *poster* is a wonderful place to put a photograph or illustration that communicates some aspect of your research question. [Maximum length: approximately 200 words.]

Materials and methods

Briefly describe experimental equipment and methods, but not with the detail used for a manuscript; use figures and tables to illustrate experimental design if possible; use flow charts (the type with text and drawings within boxes) to summarize reaction steps or timing of experimental procedures; include photograph or labeled drawing of organism; mention statistical analyses that were used and how they allowed you to address hypothesis. [Maximum length: approximately 200 words.]

Results

Brief summary of exactly what your results were. First, mention whether experiment worked (e.g., "90% of the birds survived the brainectomy"); in same paragraph, briefly describe qualitative and descriptive results (e.g., “surviving birds appeared to be lethargic and had difficulty locating seeds”); in second paragraph, begin presentation of data analysis that more specifically addresses the hypothesis; refer to supporting charts or images; provide extremely engaging figure legends that could stand on their own (i.e., could convey some point to reader if viewer skipped all other sections, which they usually do); place tables with legends, too, but opt for figures whenever possible. This is always the largest section, except if you have no data. [Maximum length: approximately 200 words, not counting figure legends.]

Conclusions

Give brief summary explaining what the data mean and how the data address your hypothesis/questions. Remind (without *sounding* like you are reminding) the reader of hypothesis and result, and quickly state whether your hypothesis was supported; discuss why your results are conclusive and interesting (attempt to *convince* reader of these points); relevance of your findings to other published work; relevance to real organisms in the real world; future directions. [Maximum length: approximately 200 words.]

Table 4.8 Key questions and associated with poster sections

Key question	Associated poster section
Why	Purpose, Research Question/Hypotheses
Who	Population and Sample
What	Variables and Instruments
When	Time period of data collection
Where	Location of population and sample
How	Methods, Procedures, Implementation
So what	Results, Future Implications, Evaluation, Conclusions, Benefits

Acknowledgements

It is a short paragraph where the researcher acknowledges the contributions of others in the research study. Thank individuals for *specific* contributions to project (equipment donation, statistical advice, laboratory assistance, comments on earlier versions of the poster); mention who has provided funding; be sincere but do not lapse too much into informality in this section; do not list people's titles. Also include in this section *explicit* disclosures for any conflicts of interest and conflicts of commitment. [Maximum length: approximately 40 words.]

References

Follow standard biology format *exactly* (don't wing this!); web sites and rumors you heard at Starbucks are equally undesirable sources: find a *journal* article that supports your needed fact. Also, if you haven't read a journal article completely (e.g., you could only view the abstract online) you may *not* cite it! [Maximum length: approximately 10 citations.]

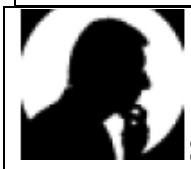
Poster presentation guidelines

In the poster session, poster presenters remain close to their posters and are available to answer questions and discuss their research findings.

Tips for a poster presenter

- ✓ Try to choose your clothes to match your poster color. Research has shown that your poster will be avoided, a bit, when you be at odds. If you are color blind or fashion-impaired, please ask somebody to help you dress.
- ✓ Do not wear a hat. Do not wear a muscle shirt. etc.
- ✓ Wear a name tag, if possible, so that viewers know that the poster belongs to you.
- ✓ Do not chew gum or tobacco
- ✓ Keep your hands out of your pockets
- ✓ Do not refer to notes when explaining your poster.
- ✓ Speak to your *viewers* as you explain your poster.
- ✓ A typical poster visitor really, really appreciates a 1-sentence overview of why your research is interesting and relevant. Get them hooked, instantly, on some unanswered question that they simply must hear more about.
- ✓ If a visitor hasn't left or yawned, you might continue on to other figures. Point to specific parts of your poster whenever possible so that viewers are aware of your progression.
- ✓ Don’t point to text and read it.
- ✓ Keep a black pen and correction fluid in your pocket in case a viewer discovers an embarrassing typo.
- ✓ If more viewers arrive halfway into your chatter, finish the tour for the earlier arrivals first.
- ✓ If you must leave your poster, affix a note alerting any viewers to your expected time of return or telling them where you can be found (e.g., which bar).
- ✓ Have on hand, but do not aggressively peddle, manuscripts and reprints of your work.
- ✓ If a person wants to take your photograph, or wants a photograph of your poster, be warned that he or she might post a very high-resolution version of your poster on an Internet site. If you have unpublished research, or research that might be deemed offensive to non-scientists, consider saying, "No, thanks", or ask them not to post the photograph.
- ✓ *Thank* your viewers for visiting. If they have stayed more than 4 minutes, you have succeeded. If they say, "This is really interesting--I'll definitely come back later," you have failed.

The great majority of bad posters are bad because the author(s) is/are trying to present too much. Huge blocks of typed material, especially if the type is small, will not be read. Crowds will gather around the simple, well-illustrated posters; the cluttered, wordy posters will be ignored.


Self Test Exercises

1. Look at the following information (Table 4.9) that contains some sections of a journal style paper. Read the experimental process (left column) and suggest the corresponding component of a scientific paper in the given spaces (right column).

Table 4.9. The sections appear in a journal style paper in the following prescribed order

Experimental process	**Section of Paper**
What did I do in a nutshell? What is the problem? How did I solve the problem? What did I find out? What does it mean? Who helped me out? Whose work did I refer to? Extra Information	

2. List some advantages and disadvantages of using overhead transparencies

3. Try to get a journal article(s) published by publishing companies such as Springer, ELSVIER, etc. Then,

a) Look at the components given in the article and compare with the ones given in your module.

b) Read each component and compare with the descriptions given in your module

4. Look at the following cases

a) Suppose that Scientist A designs a series of experiments that might result in an important new knowledge, and then Scientist A tells Technician B exactly how to perform the experiments. If the experiments worked out and a manuscript results, who should be the author (s)?

b) Now let us suppose that the above experiments do not work out. Technician B takes the negative results to Scientist A and says something like, "I think we might get this damned strain to grow if we change the incubation temperature from 24 to 37 oC and if we add serum albumin to the medium." Scientist A agrees to a trial, the experiments, this time yield the desired outcome and a paper results. In this case, who would be the author(s)?

Unit 5: How to Write a Review Paper

Unit Objectives

At the end of this chapter, the learners will be able to:

- define what a review paper is,
- elaborate the components of a review paper,
- write review paper on selected topic,
- critically evaluate the quality of a given review paper.

Introduction

Dear learner, this chapter deals with how to review or compile information related to topic selected for writing a review paper. Such writing gives readers the chance of accessing up-to-date information easily. Furthermore, it economizes the time to be spent on searching for relevant information found published at different time and on different source (journals and/or books).

5.1 What Is A Review Paper?

Activity 54

Do you think that a research paper is different from a review paper? If yes, write down as many differences as possible.

There are two main types of scientific paper: a research paper which will become part of the primary literature and a review paper which will become part of the secondary literature.

A research paper describes a new experiment, or series of experiments, conducted by the author(s). It focuses upon the outcome (results) of the experiments but will also describe the methods used and describes the implications of this experiment.

A review paper does not describe the author's own work, but rather synthesizes ideas and results from other research papers that have been published in a certain subject area. This requires a

different sort of research... a complete review of this literature in the chosen area. Moreover, a good research paper is more than a descriptive "listing" of the findings of various scientific studies, like a glorified annotated bibliography. Instead this paper should be a thoughtful integration of the results and ideas coming from a number of studies in order to provide a new perspective or understanding or to provoke discussion within that field. The conclusions of a number of studies need to be placed in perspective with one another... do they agree? If not, how might the apparent conflicts be solved? What might be productive areas to research in the future? A useful resource for a student writing a review paper are the "Annual Reviews" that are available for a number of fields including "Annual Review of Ecology and Systematics", "Annual Review of Cell and Developmental Biology" "Annual Review of Immunology" etc.

Definition

Dear reader, the comparison made above hopefully gave you the basic concept of what a review is. Accordingly, a review is a comprehensive synthesis of results from a wide and complex set of studies. A Review paper is a scientific paper written based on primary report. Overall, the paper summarizes the current state of knowledge of the topic. It creates an understanding of the topic for the reader by discussing the findings presented in recent research papers. Thus, the purpose of a review paper is to succinctly review recent progress in a particular topic sot that the readers make sense of all available information.

A scientific review paper is a critical synthesis of the research on a particular topic. It synthesizes the results from several primary literature papers to produce a coherent argument about a topic of focused description of a field. Examples of published scientific reviews can be found in *Current Opinion in Cell Biology, Current Opinion in Genetics and Development, Annual Review of Physiology, Trends in Ecology and Evolution, Annual Review of Microbiology, Botanical Review, The Biological Review*, etc. Almost every scientific journal has special review articles. For example, “Perspectives” and “Review” section of *Science* journal; “News and Views” section of *Nature*. Dear learner, read articles from one or more of the above sources to get examples of how a review paper is prepared and how to organize your paper.

5.2 How to go about writing a review paper?

Activity 55

Does preparation of a review paper requires special procedures? Discuss what possible preparations it requires.

A key aspect of a review paper is that it provides the evidence for a particular point of view in a field. Thus, a large focus of your paper should be a description of the data that support or refute that point of view. In addition, you should inform the reader of the experimental techniques that were used to generate the data. Thus, the emphasis of a review paper is interpreting the primary literature on the subject. To this effect, you need to read several original articles on the same topic and make your own conclusions about the meanings of those papers.

Review articles are written with the expectation of the readers with the same general background as the author, but without specialized knowledge of the particular topic. Scientists commonly use reviews to communicate with each other and the general public. There are a wide variety of styles from ones aimed at a general audience (e.g., *Scientific America*) to those directed to biologists within a particular sub-discipline (e.g., *Annual Review of Physiology*).

Some tip that help you when writing a scientific review paper:

- Try to make your research paper an integrated synthesis of the literature, rather than simple collection of facts,
- Give yourself enough time! For a 10-20 pages paper it ideally takes a month to carry out the library searches and to collect the necessary materials (interlibrary loans etc).
- Start out with a clear idea of the question you are trying to answer in the paper. Write it and show it to an advisor to see if it makes sense, is "do-able" etc. In general a simple, specific idea is easier to research and to write about. Equally it must be interesting and inclusive enough to ensure there's enough material available to review.

- Get to know the library. Make sure you are familiar with all the resources available to help you locate references. Take notes, including full citations (authors' names, journal, date and page number) from each paper as you read it.
- Outline your paper before starting the write-up! This will help you to organize your thoughts and will markedly improve the overall quality of your final product.
- Don't be afraid to write your ideas down before they are perfectly formed. If you can get them down on paper, you can place them in a logical sequence and develop them into a flowing presentation later.
- Use the draft system: Write a first draft. Leave it for a day or two. Come back to it and revise it as much as you can, then let someone read it. Once they have read it, revise the paper again. Respond to your reviewer's comments and also clarify any passages that seemed to confuse them. Expect that your paper will need revisions and don't feel bad when that turns out to be true.
- Don't write in the first person (I think). This reduces your credibility. Write with authority (It is, they do)

What goes into a review paper?

When writing a review paper your job is to present what is known about a specific topic and to synthesize all the unconnected threads of the individual studies into an integrated "State of the Science" type of review. Your paper should clearly outline any problems that are currently being addressed, and explain the basis of any conflicts that exist between experts in the field. If there are important conflicts as a reviewer you are in a position to suggest which side of the conflict has the weight of evidence supporting it and why. For conflicts which, in your opinion, do not yet have a clear resolution, you are also in a position to makes suggestions as to the types of experiments that need to be done to resolve those arguments.

Choosing a Topic or Title for a Review

The first step of writing of a review paper is the choice of a topic or title of the review. After deciding on the title, you can select a recent paper, text books, etc with relevance to the title you

selected for your review. Then, in the reference section of the selected literature sources you will find a list of references from various sources, which enlighten you about other useful references. Read them, take notes and use the reference sections of these papers again to further expand your resources. By doing this, you can collect the available information from the literature. As an option, once you identified recent published article on an internet, click on the 'Related Articles' dialogue to download related papers. Actually this depends on your access to internet.

The topic/title of a review paper needs to fulfill the following:

- should be interesting to the writer
- should not be so broad to be unmanageable
- should not be too narrow so that information becomes difficult to find
- should not be too difficult for the writer to fully understand it
- start with a broad topic, read about it and narrow it down gradually. It is also helpful to start with many alternative topics and choose one of them that satisfy the criteria set.

Activity 56

1. Refer to recent publications in any of the scientific journals and try to select topics for writing a review paper.

5.2.2 Sections of a Review Paper

Activity 57

Describe what contents should go into the different sections of a review paper. Compare your response to the brief description given below.

Your review paper should consist of the following sections: Title, abstract/summary, introduction, body of the paper, conclusion, acknowledgement, and literature cited. A review paper contains no materials and methods section. The inclusion of abstract in a review paper is still a controversial issue among scholars. When present, it needs to summarize the major content of the present review.

A. Title: Title of a review paper should be short and inform your reader of the major ideas that will be discussed.

B. Abstract/Summary: This should be written last and needs to summarize the major points mentioned within the body of your paper.

C. Introduction: Your introduction should be short and concise (about a page) and is not given a separate heading from the body of the paper. The purpose of the introduction is to introduce your reader to the ideas that you will be addressing in the body of your paper. In your introduction you should be trying to bring readers from different backgrounds up to speed with the "thesis" or objective of your paper and explain to them why it is that this issue is important. It is not a review of the field, which goes to the body of the paper.

It is generally written after the body of the paper is completed (so that you know where you've "gone" intellectually in the paper and thus can effectively communicate to your reader what to expect).

D. Body of the paper: In this portion of your paper you will outline the background for your idea and begin to synthesize ideas from the papers you've read in order to build a coherent "thesis". Before you write this section, figure out what your perspective is going to be (what are you trying to show?). Having done this, try to present your idea in such a way that they build your discussion logically towards your goal. Outlines will be a big help to you at this stage. Frequently using headings (e.g. History of the idea, Specific conflicts etc.) can help you to systematically address each important point that you wish to make, as well as helping your reader to follow your arguments. Once you've developed your headings you can then go back and place topic sentences for each paragraphs of information you wish to convey under the appropriate heading. Each paragraph should have clear, well thought out points, and should contain only the information needed to make or support that point. Fill in each paragraph with more details until you have a coherent argument building towards your final, concluding statement.

E. Conclusion: Like the introduction, the conclusion section is not usually separated from the body of the paper, although it can be if it is really long. In this section you should restate the objective(s) of your paper and point out how you have satisfied these goals. It should also reiterate what the major conclusions (ideas) of your study are.

F. Acknowledgements: This section should include only people who made considerable impact on your research, such as people with whom you had fruitful discussions, a librarian who spent hours with you trying to track down an elusive publication that was key to your research etc.

G. Literature Cited. This should follow the standard format outlined by the journal in which you will publish the work done.

While presenting experimental evidence in review papers, the experimental procedure should not be repeated step for step. See the following two examples and evaluate the experimental evidence were presented.

Example a:

"Indirect immunofluorescence was used to determine the sub-cellular localization of the p15 protein in Hi-5 cells. A double labeling experiment was performed with the anti-p15 antibody and anti-NP1, an antibody that recognizes a nuclear envelope protein. p15 and NP1 were found to localized, showing that..."

Example b:

"Researchers wanted to determine the sub-cellular localization of the p15 protein in Hi-5 cells. First, they fixed and permeabilized the cells. Then, they added the anti-p15 and anti-NP1 antibodies and incubated for an hour. Next, they washed the cells three times with buffer. After washing they added a rhodamine-labeled secondary antibody for the anti-p15 antibody and a fluorescein-labeled secondary antibody for the anti-NP1 antibody and incubated for one hour. Cells were then washed three times with buffer, mounted on slides, and photographed with fluorescence microscopy. This experiment revealed that the p15 and NP1 proteins localized in the cells. This finding indicates that…"

Comments:

The second example is verbose and gives too much detail about the procedure, which is not advisable. One has to tell the reader what techniques were used. In a review, one should not tell how the experiment was done. The interested reader is referred to original articles to learn the experimental details.

Answer to some of the Self Test Questions

Section 4.2.1.1 (True /False items)

1. F 2. T 3. T 4. F 5. T

Section 4.5

Table 2: The sections appear in a journal style paper in the following prescribed order

Experimental process	**Section of Paper**
What did I do in a nutshell?	Abstract
What is the problem?	Introduction
How did I solve the problem?	Materials and Methods
What did I find out?	Results
What does it mean?	Discussion
Who helped me out?	Acknowledgements
Whose work did I refer to?	References/literature cited
Extra Information	Appendix

3. Discussion. Discussion section of a scientific paper is too long and verbose in many cases.

4. Some of the advantages and disadvantages of using overhead transparencies: The overhead projector is a natural successor to the chalkboard. It is particularly useful in presentations to small groups. Overhead transparencies, as visual aids, have advantages and disadvantages.

The advantages of overhead transparencies are that:

_ they may not need to have the room darkened;

_ the speaker faces the audience, allowing better eye contact;

_ they are inexpensive to make;

_ they can be made quickly, using the copy machine or a computer printer with compatible transparent plastic sheets;

_ overhead projectors are usually readily available, are easy to set up and are less likely to break down; a projectionist is not required;

_ the speaker can write directly on the film by a marking pen;

_ information can be built up in a dynamic way by either drawing directly on the transparency, or by adding transparent overlays;

_ colour can be easily used.

The disadvantages of overhead transparencies are that:

_ they are not suitable for large audiences;

_ the projected image is not as sharp as the slide;

_ the projector cannot be put in a projection booth;

_ they can give the impression of being prepared in haste if not carefully revised and well presented.

3. The answer will be given during tutorial sessions.

4. **a) Answer:** Scientist A should be the sole author, even though Technician B did all the work. (Of course, the assistance of Technician B should be recognized in the Acknowledgements).

b) Answer: Scientist A and Technician B, in that order, should both be listed as authors. In short, the scientific paper should list as authors only those who contributed substantially to the work.

Annex

Committee on Professional Training

Preparing a Research Report

Research experience is as close to a professional problem-solving activity as anything in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty advisor. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation. Ideally, undergraduate research should focus on a well-defined project that stands a reasonable chance of completion in the time available. A literature survey alone is not a satisfactory research project. Neither is repetition of established procedures. The Committee on Professional Training (CPT) strongly supports efforts by departments to establish active and vibrant undergraduate research programs, recognizing the role that research can play in developing a wide range of student skills. The 2008 guidelines allow for the use of undergraduate research both as in-depth coursework, as well as a means of meeting 180 of the 400 laboratory hours required for certification provided that a well-written, comprehensive, and well-documented research report is prepared at the end of a project (samples of such research reports must be submitted with the periodic reports.) The CPT has a separate supplement outlining the components of successful research programs and projects.

Preparation of a comprehensive written research report is an essential part of a valid research experience, and the student should be aware of this requirement at the outset of the project. Interim reports may also be required, usually at the termination of the quarter or semester. Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critiqued by the faculty advisor and

corrected by the student at each stage. It may be expected that concrete outcomes of any research project would be student presentation of research results at a professional meeting and/or co-authorship on a journal publication. However, while this is a most desirable outcome, it is not a substitute for a well-written comprehensive report, produced by the student with substantive critique and correction by the faculty mentor, which demonstrates that the student has a full grasp of the scope of the problem, the techniques/instrumental methods used, and the ramifications of the results generated (much as might be expected for a capstone paper or a B.S. thesis). It is of paramount importance that any undergraduate research project culminates in a thorough well-documented written report.

Guidelines on how to prepare a professional-style research report are not always routinely available. For this reason, the following information on report writing and format is provided to be helpful to undergraduate researchers and to faculty advisors. Much of what follows is similar to what authors would find in many 'guidelines to authors' instructions for most journal submissions.

The most comprehensive reports examined by CPT have been those student reports reviewed by more faculty than just the supervising research advisor. In some cases, departments require an approval of the report by several faculty members; in such cases, student research reports are often of high quality.

Organization of the Research Report

Most scientific research reports, irrespective of the field, parallel the method of scientific reasoning. That is: the problem is defined, a hypothesis is created, experiments are devised to test the hypothesis, experiments are conducted, and conclusions are drawn. The exact format of scientific reports is often discipline dependent with variations in order and content. The student is encouraged to adopt the format that is most appropriate

to the discipline of the research. Many journals offer a formatting template to aid the author. One example of such a framework is as follows:

• Title

• Abstract

• Introduction

• Experimental Details or Theoretical Analysis

• Results

• Discussion

• Conclusions and Summary

• References

Title and Title Page

The title should reflect the content and emphasis of the project described in the report. It should be as short as possible and include essential key words.

The author's name (e.g., Mary B. Chung) should follow the title on a separate line, followed by the author's affiliation (e.g., Department of Chemistry, Central State College, Central, AR 76123), the date, and possibly the origin of the report (e.g., In partial fulfillment of a Senior Thesis Project under the supervision of Professor Danielle F. Green, June, 1997).

All of the above could appear on a single cover page. Acknowledgments and a table of contents can be added as preface pages if desired.

Abstract

The abstract should concisely describe the topic, the scope, the principal findings, and the conclusions. It should

be written last to reflect accurately the content of the report. The length of abstracts varies but seldom exceeds 200 words. A primary objective of an abstract is to communicate to the reader the essence of the paper. The reader will then be the judge of whether to read the full report or not. Were the report to appear in the primary literature, the abstract would serve as a key source of indexing terms and key words to be used in information retrieval. Author abstracts are often published verbatim in Chemical Abstracts.

Introduction

"A good introduction is a clear statement of the problem or project and the reasons for studying it." (The ACS Style Guide. American Chemical Society, Washington, DC, 2006.)

The nature of the problem and why it is of interest should be conveyed in the opening paragraphs. This section should describe clearly but briefly the background information on the problem, what has been done before (with proper literature citations), and the objectives of the current project. A clear relationship between the current project and the scope and limitations of earlier work should be made so that the reasons for the project and the approach used will be understood.

Experimental Details, Computation Procedures, or Theoretical Analysis

This section should describe what was actually done. It is a succinct exposition of the laboratory and computational details, describing procedures, techniques, instrumentation, special precautions, and so on. It should be sufficiently detailed that other experienced researchers would be able to repeat the work and obtain comparable results.

In theoretical reports, this section would include sufficient theoretical or mathematical analysis to enable derivations and numerical results to be checked. Computer programs

from the public domain should be cited. New computer programs should be described in outline form.

If the experimental section is lengthy and detailed, as in synthetic work, it can be placed at the end of the report so that it does not interrupt the conceptual flow of the report. Its placement will depend on the nature of the project and the discretion of the writer.

Results

In this section, relevant data, observations, and findings are summarized. Tabulation of data, equations, charts, and figures can be used effectively to present results clearly and concisely. Schemes to show reaction sequences may be used here or elsewhere in the report.

Discussion

The crux of the report is the analysis and interpretation of the results. What do the results mean? How do they relate to the objectives of the project? To what extent have they resolved the problem? Because the "Results" and "Discussion" sections are interrelated, they can often be combined as one section.

Conclusions and Summary

A separate section outlining the main conclusions of the project is appropriate if conclusions have not already been stated in the "Discussion" section. Directions for future work are also suitably expressed here.

A lengthy report, or one in which the findings are complex, usually benefits from a paragraph summarizing the main features of the report - the objectives, the findings, and the conclusions.

The last paragraph of text in manuscripts prepared for publication is customarily dedicated to acknowledgments. However, there is no rule about this, and research reports or senior theses frequently place acknowledgments following the title page.

References

Thoroughness and currency of literature references acknowledge foundational work, direct the reader to published procedures, results, and interpretations, and play a critical role in establishing the overall scholarship of the report. The report should include in-text citations with the citations collated at the end of the report and formatted as described in The ACS Style Guide or using a standard established by an appropriate journal. The citation process can be facilitated by using one of several available citation software programs. In a well-documented report, the majority of the references should come from the primary chemical literature, with any citation of Internet sources kept to a bare minimum.

Preparing the Manuscript

The personal computer and word processing have made manuscript preparation and revision a great deal easier than it used to be. It is assumed that students will have access to word processing and to additional software that allows numerical data to be graphed, chemical structures to be drawn, and mathematical equations to be represented. These are essential tools of the technical writer. All manuscripts should be carefully proofread before being submitted. Preliminary drafts should be edited by the faculty advisor (and/or a supervising committee) before the report is presented in final form.

Useful Texts

Writing the Laboratory Notebook, Kanare, H. M., American Chemical Society, Washington, DC, 1985.

This book describes among other things the reasons for note keeping, organizing and writing the notebook with examples, and provides photographs from laboratory notebooks of famous scientists.

ACS Style Guide: Effective Communication of Scientific Information, Coghill, A. M., Garson, L. R.; 3rd Edition, American Chemical Society, Washington, DC, 2006.
This volume is an invaluable writer's handbook in the field of chemistry. It contains a wealth of data on preparing any type of scientific report and is useful for both students and professional chemists. Every research laboratory should have a copy. It gives pointers on the organization of a scientific paper, correct grammar and style, and accepted formats in citing chemical names, chemical symbols, units, and references.

There are useful suggestions on constructing tables, preparing illustrations, using different fonts, and giving oral presentations. In addition, there is a brief overview of the chemical literature, the way in which it is organized and how information is disseminated and retrieved. A selected bibliography of other excellent guides and resources to technical writing is also provided. See also The Basics of Technical Communicating. Cain, B. E.; ACS Professional Reference Book American Chemical Society: Washington, DC, 1988.

Write Like a Chemist, Robinson, M. S., Stoller, F. L., Costanza-Robinson, M. S., Jones, J. K., Oxford University Press, Oxford, 2008.
This book addresses all aspects of scientific writing. The book provides a structured approach to writing a journal article, conference abstract, scientific poster and research proposal. The approach is designed to turn the complex process of writing into graduated, achievable tasks.

Books for further reading

1. Research Methodology, A modular text of graduate studies and research of Addis Ababa University, Addis Ababa.
2. Tsige Ketema, Ketema Bacha, and Diriba Muleta (2012). Research methods and report writing; distance module for biology students.
3. Mekonnen Asefa and Fasil, Resarch methodology for health, 2005
4. M.S. Robinson, F.L. Stoller, M.S. Costanza-Robinson, J.K. Jones, *A guide and Resource, Write Like A Chemist*, Oxford University Press, Inc., New York, 2008
5. H.S. Roberts, S. Roberts, *Writing for Science and Engineering: Papers, Presentations and Reports*, Butterworth-Heinemann, 2002.
6. *How to Write And Publish A Scientific Paper*