CHAPTER 12

Results

12.1 OVERALL

The Results section is the major scientific contribution of your study. Whereas the Introduction provides background information and states the purpose/question of the paper, and the Discussion confers what your data mean when tied in to current knowledge and theories, the Results section represents the core or skeleton that may be of interest much longer than any conclusions drawn from your observations.

12.2 CONTENT

General Content

RESULTS GUIDELINE 1:
Report your main findings as well as other important findings.

RESULTS GUIDELINE 2:
Point the reader to the data shown in figures and tables.

RESULTS GUIDELINE 3:
Include control results.

The Results section presents the results of your experiments and points the reader to the data shown in the figures and tables. You should report only results that are pertinent to the information provided in the Introduction and to the experiments described in Materials and Methods. Exclude preliminary results and results that are not relevant. Do not forget to include control results, however, and if needed, explain the purpose of an experiment shortly. Also incorporate results whether or not they support your hypothesis, and explain any contradicting results if necessary.

Other important findings may consist of additional supportive evidence or alternate measurements as well as additional results that may not be part of the main story if they are meaningful for the paper. Know that not every result that you obtained from your experiments and not every observation you made has to be reported in the Results section. Concentrate on the most relevant findings; but when deciding what to include or not, know the difference between leaving out irrelevant results and suppressing contradictory ones. Do not omit the latter.

If you find that you need to collect more data as you write, do so. It is more important to do a thorough job than to submit an incomplete manuscript quickly.

Interpreting Data

RESULTS GUIDELINE 4:

Interpret your data for the reader.

In the Results section, do not just present data, but summarize and interpret their meaning for the reader by presenting them as results. Only data that have been interpreted will be meaningful for your readers.

To present your results to the reader clearly, you need to distinguish between data and results. Data are values derived from scientific experiments (concentrations, absorbance, mean, percent increase). Results interpret data (e.g., "Absorbance **increased** when samples were incubated at 25°C instead of 15°C"). Although most data should be presented in figures and tables, your main findings should be stated in the text as well along with your interpretations of all data. When you state your interpretations/results, ensure that you make reference to your data in figures or tables by referencing the figure or table number in parenthesis.

Example 12-1 — **Presenting data without interpretation**

Heart rate was 100 beats per minute after digitalis was added (Fig. 3).

Unless your readers are physicians, they may not be able to put "100 beats per minute" into any relation, especially if no comparative value is given. You need to let them know whether this is higher or lower than normal.

Revised Example 12-1 a

Heart rate ***increased* to 100 beats per minute** after digitalis was added (Fig. 3).

In the revised example, the data have been interpreted and are presented as a result, making the revised example much more meaningful for the reader.

To put the results into relation for nonspecialists in the field, you need to give comparative values as well.

Revised Example 12-1 b

Heart rate **increased *from 60 to* 100 beats per minute** after digitalis was added (Fig. 3).

When the magnitude of change is given by a comparative value ("... from 60 to 100 ..."), the data have been interpreted such that it is understandable for most scientists.

Here is another example of providing data without interpretation or explanation:

Example 12-2 — **Presenting data without interpretation**

The sequences for the proteins K 309 and K 415 were compared (Fig.4).

This example fails to interpret the data provided. The author neither explains nor analyzes the data for the reader but simply refers the reader to a figure. As a consequence, the reader does not know if the data are similar or different. Instead, the reader is expected to interpret the data himself or herself. The author should make the point clear so readers do not have to find their own interpretations.

Revised Example 12-2

When the sequences for the proteins K 309 and K 415 were compared, **their C-terminal sections were found to be 90% homologous (Fig. 4).**

The following is yet another example in which an author presents data but fails to interpret them:

Example 12-3 — **Presenting data without interpretation**

Among the 785 HIV positive participants in the study group, we found 622 men and 163 women.

To interpret the data for the reader, the author needs to first present the interpretation and then the data that supports it.

Revised Example 12-3

We found that 3.8 times as many men (79.2%) than women (20.8%) tested positive for HIV in our study group.

Presenting Data and Statistical Information

RESULTS GUIDELINE 5:

Place statistical information with data. Do not use it instead of results.

Understanding statistical information in research articles can be problematic. Often readers blame themselves for not comprehending what has been written. However, the true reason for their comprehension problems lies in the misrepresentation of statistical information.

To avoid confusing readers, make reference to the event you are referring to:

Example 12-4 **Presenting data without reference**

There is a 20% chance of a big earthquake in California.

Sentences such as the preceding one in which no reference class is given result in much misunderstanding among your readers. Readers interpret this sentence in various ways: 20% *of the area* of California has a big chance for an earthquake, or 20% *of the earthquakes* in California are big, or 20% *of the time* the chances for an earthquake are big.

Confusion can be reduced by specifying a reference class, such as time and area, before giving a single event probability.

Even more confusing are sentences that talk about more than one statistical result at a time such as in the following example:

Example 12-5 **Confusing description of statistical data**

The probability of contracting XDR TB is 80% for HIV patients. For people with XDR TB, the probablility that it will be detected through rapid skin tests is 50%. In 10% of the cases, rapid skin tests do not detect XDR TB.

This type of example leads readers to wide misinterpretations, and such misinterpretations, particularly in the medical field, can have severe consequences for patients.

If we were to restate the example using numbers rather than probabilities, the example becomes much easier to understand and more graspable.

Revised Example 12-5

Out of 100 HIV patients, 80 contract XDR TB. Of these, 40 cases will be detected through rapid skin tests. For 8 out of the 80 XDR TB cases (or 1 in 10), rapid skin tests do not detect XDR TB.

Readers usually profit from representing statistical information using numbers or frequencies rather than probabilities or sensitivities.

Many students and novice writers come up with tedious lists of statistical test results rather than a description and interpretation of experimental observations for their Results section. When you report statistical information, include descriptive statistics such as mean, standard deviation, confidence intervals, p values, and sample size as well as bivariate analysis such as chi-square or t test or multivariate analysis such as regression analysis. Ensure that you interpret descriptive statistics for your readers. Do not just list them in your Results section. Statistical analysis should serve as reinforcement for your data and should not replace their interpretation. Therefore, preferably place statistical information in your figure legends or tables or in parenthesis following the description of data.

Example 12-6 **Preferred placement of statistical information**

Vaccination rates among the elderly was higher than among younger participants when the risk of flu was high (61.6% vs. 46.8%; OR = 2.67, 95% CI = 1.94–3.67).

A good resource in providing background material on basic statistics is, for example, J. L. Fleiss, *Statistical Methods for Rates and Proportions*, by John Wiley & Sons, 1981.

12.3 ORGANIZATION

Overall Organization

RESULTS GUIDELINE 6:

Place results that answer the question of the paper at the beginning of the results section.

RESULTS GUIDELINE 7:

Organize the Results section chronologically or from most to least important.

RESULTS GUIDELINE 8:

Emphasize and signal your results. Subordinate secondary information.

Start the Results section by presenting your main findings in the first paragraph. Your main findings are the findings used in providing the overall answer/conclusion of the paper. You may also start the first paragraph with a brief overview of your general observations and then move on to the main findings (see Example 13-20). In the latter case, do not devote more than a few sentences to any overview, and ensure that your main findings still appear in the first paragraph, as it is a power position.

In subsequent paragraphs, present your specific observations. The overall structure of this remainder of the Results section is normally either chronological or from most to least important. Use topic sentences to provide an overview of each experiment. Start each subsection or paragraph by explaining the purpose of the experiment, by giving a short background, or by stating the results of an experiment (see *Organization Within Results Segments* for a more detailed explanation). Consider also including a paragraph or two describing specific details of an observation. Readers will understand papers better if specific details are highlighted or given as examples.

Throughout the Results section, emphasize the data and their meaning. Subordinate control results and methods.

The following is an example of a paragraph in a Results section. The topic sentence of this paragraph does not present the main findings but rather points the reader to a figure, thus emphasizing the figure rather than the results. Note that in general, mentioning of a table or figure is best if it is done in parenthesis rather than in the text, as tables and figures are considered supporting evidence and not results.

Example 12-7 **Results paragraph emphasizing figure rather than results**

Topic sentence does not emphasize results

Generalized results

Details of results

ESI-MS/MS of free anthraquinones. The mass spectra of five free anthraquinones identified in rhubarb are shown in Figure 3. ESI-MS of anthraquinones appeared to provide more structural information than APCI-MS did as reported previously [28]. In the MS/MS spectrum of chrysophanol, a product ion at *m/z* 225 was observed, resulting from the direct loss of CO from $[M - H]^-$. The *m/z* 225 ion was very stable and did not yield any further fragmentation. We believe that the CO elimination may originate from C-10, since the carbonyl group at C-9 has intramolecular hydrogen bonding with the α-hydroxyl groups at C-1 and C-8 and is, thus, difficult to be cleaved.

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To emphasize results, the author should have subordinated the reference to the figure.

Revised Example 12-7

Topic sentence emphasizes results

Details of results

ESI-MS/MS of free anthraquinones. **The ESI-MS fragmentation behavior of five free anthraquinones identified in rhubarb was different from that in APCI-MS reported previously (28) (Figure 3).** In the MS/MS spectrum of chrysophanol, a product ion at *m/z* 225 was observed, resulting from the direct loss of CO from $[M - H]^-$. The *m/z* 225 ion was very stable and did not yield any further fragmentation. We believe that the CO elimination may originate from C-10, since the carbonyl group at C-9 has intramolecular hydrogen bonding with the α-hydroxyl groups at C-1 and C-8 and is, thus, difficult to be cleaved.

Organization Within Results Segments

RESULTS GUIDELINE 9:

Organize your Results into different segments. In each segment, state:

Purpose or background of experiment
Experimental approach
Results
Interpretation of results (optional for descriptive papers)

To organize your Results section, think of it in different segments. Each segment pertains to one set of experiments. Many, if not most, segments will be only one paragraph long; others may be longer. You may even consider dividing your Results section into different subsections, making use of the separate segments.

Information in these Results segments or paragraphs needs to be organized. This also includes the first paragraph. Each segment that describes results of a specific individual experiment should contain four essential components:

1. Purpose or background of experiment if needed
2. Experimental approach
3. Results
4. Interpretation of results

Start your segments or paragraphs by providing a topic sentence. This topic sentence usually indicates the purpose of the experiment

performed. It may also provide context in form of background information. The purpose is followed by a short statement of your experimental approach (about half a sentence). The purpose may be written in the form of a transitional phrase or clause, for example. Follow the experimental approach immediately with your results for the experiment. Place important or general results first and less important details later in the segment/paragraph. Last, give an interpretation of your results to make them meaningful for the reader. Note that you should signal all of these elements (see Section 12.5).

It is important that you do not simply list your data—instead, *interpret* your data for the reader. Your interpretations should be limited to 1 to 2 sentences in the Results section. Avoid any lengthy interpretations, speculations, or conclusions. Save such detailed discussions for the discussion section.

The following is a well-formed paragraph/segment of a Results section:

Example 12-8 **Well-formed Results segment**

Background	**1**Considerable evidence suggests that ATP is needed in the binding of mRNA to the 40S ribosomal subunits (13).
Purpose	**2**To understand the interaction between ATP and mRNP particles better, **3**we incubated the mRNP particles with
Experimental approach	^{14}C ATP at optimal concentrations for *in vitro* yeast translation. **4**Results indicate that ^{14}C ATP bound to mRNP par-
Results	ticles, but the binding decreased about 4-fold when the temperature increased from 4 to 17°C (Fig. 1). **5**These
Interpretation Results	results suggest that the binding between ATP and mRNP particles may be governed by interactions such as hydrogen bonds or van der Waals that weaken when temperature rises.

In Example 12–8, the first sentence gives a short background, sentence 2 states the purpose/question, and sentence 3 explains the experimental approach. Sentence 4 gives the results, whereas sentence 5 interprets them. Note that data are presented in a figure (Fig. 1), and the description of the figure is subordinated. Thus, the actual results are emphasized.

Special Case: Organization of Descriptions

For descriptive papers, list your results and descriptions by describing what you discovered. These descriptions often do not need an interpretation. Instead, provide conclusions and implications in the Discussion section.

Example 12-9 **Results segment in a descriptive paper**

Purpose	To characterize the protease, various known protease
Experimental approach	inhibitors were tested for their effect on the proteolytic cleavage of the fusion protein. None of the inhibitors, antipain, aprotinin, chymostatin, EDTA, leupeptin, p-chloromercurobenzoate, pepstatin, phenylmethyl-sulfonylchloride, or soybean trypsin inhibitor, significantly slowed the rate of cleavage (data not shown). However, the bivalent cations Zn++, Cu++, and Co++ were found to inhibit the protease to near completion when added to spheroplasts before lysis (Fig. 2-6). Benzamidine addition resulted in only partial inhibition. Addition of any of the inhibitors or cations after cell lysis did not inhibit the protease activity.
Results	

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12.4 IMPORTANT WRITING PRINCIPLES FOR THE RESULTS

Word Choice

RESULTS GUIDELINE 10:
Pay attention to word choice.

Words in the Results section should be chosen carefully. Choose the most precise and descriptive wording that reflects what you want to say, but keep wording simple. Consider the following example:

Example 12-10 **Choice of words**

Mg^{2+} binds to the complex and increases complex formation, reaching an optimum at 4 to 10 mM (Fig. 2D). K^+, on the other hand, has the *opposite effect* on complex formation, *reaching its optimum at 0 mM* K^+ (Fig. 2E).

What does the author want to say in the second sentence? What is the "opposite effect," and how can an optimum be "*reached*" at 0 mM? The opposite of *increase* is *decrease* or *inhibition*, and an optimum can never be *reached* at 0 mM, no matter what reagent is added. What the author intends to state here is that K^+ inhibits the formation. Thus, the second part of sentence 2 should be omitted entirely because the word *inhibition* already implies the effect. The revision simplifies and clarifies what the author is trying to say.

Revised Example 12-10

Mg^{2+} binds to the complex and increases complex formation, reaching an optimum at 4 to 10 mM (Fig. 2D). **K^+, on the other hand, *inhibits* complex formation (Fig. 2E).**

ESL advice

In addition to using simple, precise words and avoiding jargon and repetitive words, you should pay particular attention to the following

CHAPTER 9

Figures and Tables

Figures and tables are meant to demonstrate evidence visually and therefore should be designed for strong visual impact. As readers often look at figures and tables to see whether the rest of a paper is worth reading, each figure and table should be capable of standing on its own without reference to the text.

9.1 GENERAL GUIDELINES

ILLUSTRATION GUIDELINES:

1. Figures and tables should be able to stand on their own.
2. Decide whether to present data in a table, a figure, or in the text.
3. Use the fewest figures and tables needed to tell a story.
4. Design figures and tables to have strong visual impact.

Decide first whether to present your findings in a figure, in a table, or in the text. Editors and reviewers will stringently judge if a figure or table is useful. Each figure or table should therefore be important enough to be included in a document. Your reader can also pull the story together more easily from 5 or 6 figures and tables than from 15 or 16. Be aware that figures and tables take longer to create and may cost more to produce than text.

Figures and tables must clearly and accurately show what the text states. For example, if the text describes a new organism, the important features of this organism should be immediately visible in the figure. Similarly, if the text says that when X was done, Y increased, then in the figure, Y should look as if it increased. If the increase is not obvious, the figure is unconvincing.

At the same time, figures and their legends as well as tables and their titles must be independent of the text and of each other, that is, they must be able to stand on their own. Figures and tables need to be numbered in the order they appear in the text. In addition, the name of the variable, the unit of measurement, and the values should be the same in the text and in the illustration. If possible, provide statistical information in figures and tables.

For a very detailed description of "dos" and "don'ts" for figures and tables, see also Rubens (1992, pp. 327–423.)

9.2 IMPORTANCE OF FORMATTING AND PLACEMENT OF INFORMATION

GUIDELINE 1:

Prepare figures and tables with the reader in mind—place information where the reader expects to find it.

In the same way that text should be formatted for the reader, figures and tables should be formatted to meet the reader's expectations. Most readers

can understand the intended meaning of what is presented only if the illustration has been formatted for this interpretation.

Scientists can present data in different formats. See Example 9.1, including Tables 9.1, 9.2, and 9.3, for various possibilities for a set of data.

Example 9-1

a

0 °C, 0.011% hermaphrodites
6 °C, 0.011% herm.
25 °C, 51/1000
water T = 30 °C , 0.124%
35 °C, 0.152%

18 °C, 0.028%
T = 10 °C , 2/100

b Table 9-1: Sample Data Display 1

% HERMAPHRODITES N = 120	WATER TEMPERATURE (°C)
0.011	0
0.011	6
0.020	10
0.028	18
0.051	25
0.124	30
0.152	35

c Table 9-2: Sample Data Display 2

Water temperature (°C)	0	6	10	18	25	30	35
% Hermaphrodites	0.011	0.011	0.020	0.028	0.051	0.124	0.152

d Table 9-3: Sample Data Display 3

WATER TEMPERATURE (°C)	% HERMAPHRODITES
0	0.011
6	0.011
10	0.020
18	0.028
25	0.051
30	0.124
35	0.152

Although the exact same information appears in all formats, most readers prefer Example 9-1d because it is the easiest to interpret. The reason for the easier interpretation is twofold: (a) the data is written as a table, and, even more important, (b) this table is structured such that the familiar context (temperature) appears on the left, whereas the interesting results appear on the right in a less obvious pattern.

Usually, information in a table is more readily available for readers than information in the text (unless there are very few data). However, some tables are easier to interpret than others. For example, readers find tables much harder to follow if they are presented as shown in Example 9-1b (Table 9.1), or if the table is horizontally arranged as in Example 9-1c (Table 9.2). Readers interpret information more easily if it is placed where they expect to find it. Because we read from left to right, we prefer the familiar context on the left and the new information on the right as in Example 9-1d (Table 9.3).

9.3 FIGURE OR TABLE?

FIGURES GUIDELINE 1:

Use figures to show trends and relationships and to emphasize data.

When you have chosen to use an illustration rather than text, you may then need to decide in what format to present them, figure or table. It helps if you spread your data out on the table and arrange them in all possible combinations. Look for patterns. There are better and worse presentations of data in a paper. Go with a simple pattern if possible.

Generally, choose figures when trends or relationships are more important than exact values or when hidden relationships or trends need to be revealed. Choose tables to report precise numerical information, to compare component groups, or when data are not enough to produce a satisfactory graph.

Consider the next two illustrations (Example 9.2; Table 9.4). Which of the following presentations would you prefer given the same data?

Example 9-2 **a Table 9-4: Sample Data Presentation A**

TIME (DAYS)	HORMONE A	HORMONE D54
0	200.5	455.8
5	187.1	356.7
10	166.5	321.9
15	201.1	400.6
20	289.8	500.7
25	204.1	489.9

TIME (DAYS)	HORMONE A	HORMONE D54
30	189.9	389.4
35	288.9	513.4
40	205.1	499.3
45	182.9	298.5
50	278.8	533.2
55	223.4	498.5
60	199.6	250.6

Example 9-2 b

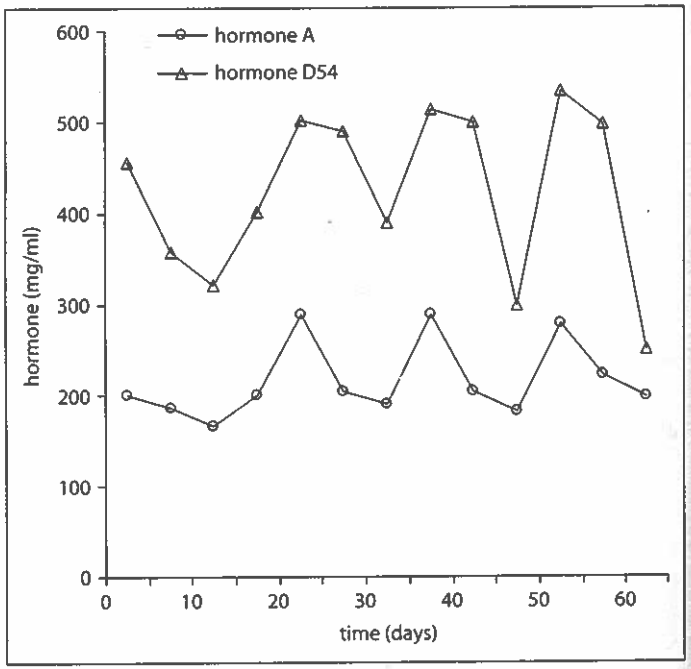

Figure 9.1: Sample data presentation B. The same data as in Example 9-2a are presented as a line graph instead of a table.

Most readers would prefer Example 9-2b (Figure 9.1) because the trend and relationship of the data is more obvious, and exact numbers seem not as important.

Consider another example in Figure 9.2.

Example 9-3

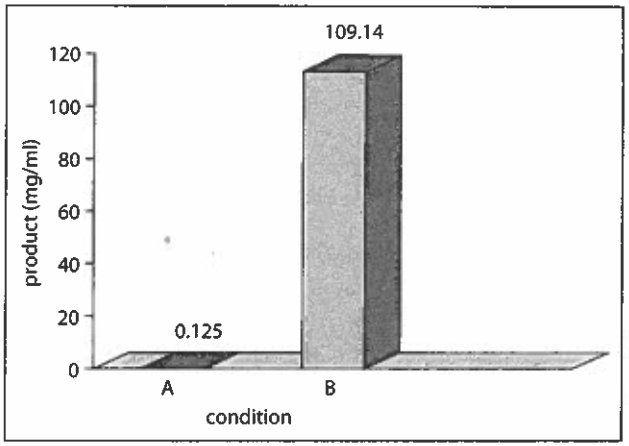

Figure 9.2: Bar graph

Example 9-3 would best be depicted in the text because there are only two data points, and exact values seem important.

9.4 GENERAL INFORMATION ON FIGURES

General Advice

When you prepare a figure, be sure that it carries your point better than the text or a table would. Never use figures simply because they are available. Consider what kind of figure you need. You can choose to present your data in a **photograph**, a **drawing**, a **diagram**, or a **graph**. Select the size and format to fit the journal, poster, or slide.

Overall, figures must be simple and clear enough for readers to get the message immediately. Good figures clarify relationships of complicated data sets and highlight trends or patterns that may not be immediately evident in the text.

The requirements for figures that will appear in print are different from those for oral presentations or posters (see Table 9.5 and also Chapter 27 and 28). Although it is best to design for each medium separately, if you plan carefully, you may be able to use the same artwork for a journal article, an oral presentation, and a poster presentation.

Table 9.5 Differences between figures in text, slides, and posters

	TITLE	LEGEND
Figure in text	—	✓
Figure on slide	✓	—
Figure on poster	✓	✓
Table in text, on slide or poster	✓	—