Handbook of Biomedical Research Writing:
The Results and Discussion Section

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This edition is currently being revised. Please email suggestions or corrections to jocelyngraf@gmail.com and adamturner7@gmail.com

4.0 The Results and Discussion Sections

The results and discussion sections present your research findings and your analysis of those findings. A few papers also contain a conclusion section, which usually focuses on practical application or provides a short summary of the paper. The results, discussion and conclusion sections are combined into one chapter in this book because they are sometimes combined in journal articles. Most articles do not contain all three sections.

4.1 The Purpose of the Results and Discussion Sections

To review, the traditional journal article in the sciences consists of four parts: Introduction, Methods, Results, and Discussion/Conclusion (IMRD). They answer these questions:

- Why do we care about the problem and the results?
- What problem are you trying to solve?
- How did you go about solving or making progress on the problem?
- What's the answer?
- What are the implications of your answer?

The last two questions are the object of the results and discussion sections, respectively. If a paper contains a conclusions section, it also focuses on implications.

4.2 The Structure of the Results Section

The *Annals of Internal Medicine*'s Information for Authors provides the following advice for preparing the results section of a clinical journal article:

> Fully describe the study sample so that readers can gauge how well the study findings apply to their patients (external validity). Then present primary findings followed by any secondary and subgroup findings. Use tables and figures to demonstrate main characteristics of participants and major findings. Avoid redundancy between text and tables and figures.

> *Annals of Internal Medicine.* Information for Authors.
> http://www.annals.org/shared/author_info.html#manuscript-text . Retrieved 3 February 2008.

In clinical medicine, there are a number of organizations of scholars that have developed regulations for reporting on various types of studies. Before drafting your article, even if you plan to publish in a smaller journal, check the author's guidelines of a major journal for a list of these recommendations. *The Annals of Internal Medicine* and *BMJ* have excellent detailed author's guidelines and links to checklists. For example, the following is an excerpt from the checklist for studies of diagnostic accuracy. The group of scholars is named "STARD."

STARD checklist for reporting of studies of diagnostic accuracy: Results section

Section and Topic	Information to Be Included
RESULTS	
Participants	When study was performed, including beginning and end dates of recruitment.
	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).
	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).
Test results	Time-interval between the index tests and the reference standard, and any treatment administered in between.

	Distribution of severity of disease (define criteria) in those with the target condition; other diagnoses in participants without the target condition.
	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.
	Any adverse events from performing the index tests or the reference standard.
Estimates	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).
	How indeterminate results, missing data and outliers of the index tests were handled.
	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.
	Estimates of test reproducibility, if done.

Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig LM, et al. Towards complete and accurate reporting of studies of diagnostic accuracy: the STARD initiative. Standards for Reporting of Diagnostic Accuracy. Clin Chem. 2003 Jan;49(1):1-6. Review. Download the whole STARD checklist here: http://www.equator-network.org/index.aspx?o=1050

Biomedical researchers doing basic science can follow a more flexible structure, depending on the nature of the study and the journal. The sample description for experimental papers would typically appear in the methods section, not the results, as mentioned above for clinical papers. Start with the most important finding, and continue through each result in a logical way. This may be according to time, if one result followed from the next, or it may be from most to least important. An example is provided later in this chapter, in the section entitled "Results Structure of an Experimental Study in the IRD(m) Format."

4.3 The Structure of the Discussion Section

According to the Instructions for Authors of the *Journal of the American Medical Association (JAMA)*, the discussion section is "a comment section placing the results in context with the published literature and addressing study limitations."

JAMA. Instructions for Authors. http://jama.ama-assn.org/misc/ifora.dtl#ManuscriptComponents. Retrieved on 3 February 2008.

Similarly, *Cell*'s Instructions for Authors stipulates that "the Discussion should explain the significance of the results and place them into a broader context. It should not be redundant with the Results section. This section may contain subheadings and can in some cases be combined with the Results section."

Cell. Information for Authors. http://www.cell.com/misc/page?page=authors#SubmissionRA . Retrieved on 3 February 2008.

Interestingly, because *Cell* does not have a clinical focus, the role of discussing limitations is not central enough to mention in the Instructions for Authors. In fact, unlike clinical journals, journals like *Cell* that publish long experimental reports are more likely to allow combining the results and discussion into a single section and may not contain a conclusion section at all.

Turner notes that the discussion section is a mirror image of the introduction. While the introduction starts with general background information and moves to the specific purpose of the author's research, the discussion starts with an analysis of the author's own specific results and moves to general implications of the research.

Turner A. *English Solutions for Engineering Research Writing*. 2006.

Tip
The *Annals of Internal Medicine* journal's Information for Authors offers these recommendations for structuring the discussion section:

1. Provide a brief synopsis of key findings, with particular emphasis on how the findings add to the body of pertinent knowledge.

2. Discuss possible mechanisms and explanations for the findings.
3. Compare study results with relevant findings from other published work. Briefly state literature search sources and methods (e.g., English-language MEDLINE search to Jan 2007) that identified previous pertinent work. Use tables and figures to help summarize previous work when possible.
4. Discuss the limitations of the present study and any methods used to minimize or compensate for those limitations.
5. Mention any crucial future research directions.
6. Conclude with a brief section that summarizes in a straightforward and circumspect manner the clinical implications of the work.

4.4 Examples of Results and Discussion Sections

4.4.1 Clinical Study Results and Discussion Structure with Traditional IMRD Format

Below is presented most of the text from the results and discussion sections of a clinical report on the relationship between eating meat and getting various types of cancer.

Note: It was possible to reprint long excerpts of this journal article thanks to the *PLoS Medicine* journal's generous open-access policy. For more details, see http://journals.plos.org/plosmedicine/license.php .

Comments	Results Section
The first sentence of the results section summarizes the procedure detailed previously in the methods section. A summary of the findings for the first variable—red meat intake—is provided.	During a mean follow-up of 6.8 y, 53,396 cancer diagnoses (36,907 male cases and 16,489 female cases) were ascertained. The mean energy–adjusted red meat intake in this cohort was 34.6 g/1,000 kcal (38.0 g/1,000 kcal in men and 29.5 g/1,000 kcal in women). The medians of extreme quintiles ranged from 9.8 to 62.7 g/1,000 kcal for red meat and 1.6 to 22.6 g/1,000 kcal for processed meat.
The characteristics of patients studied are related to the amount of meat that they eat.	In general, those in the highest quintile of red meat intake tended to be . . . [demographic characteristics, habits and health] (Table 1).
The first subheading. Within this section, results for the first of two types of meat are presented. First: A list of all the types of cancer risk increased by eating red meat. Next: statistical procedures that clarified the connection between meat and cancer was not related to other causes.	**Red Meat** Individuals in the highest quintile of red meat intake, compared with those in lowest, had a statistically significant elevated risk of several malignancies (Table 2), including esophageal, . . . colorectal, . . . liver, . . . lung, and borderline statistical significance for laryngeal cancer . . . The positive association for red meat intake and colorectal cancer was due more to cancer of the rectum . . . than the colon, . . . Additional fine control for smoking did not alter the associations for cancers of the esophagus, colorectum, liver, lung, or larynx. In addition, the tests for interaction between smoking and both red meat . . . and processed meat . . .

	intake for lung cancer risk were not statistically significant. . .
A list of cancer types not related to eating red meat.

Reference to a figure that contains the data of the first two paragraphs. | Red meat intake was not associated with gastric or bladder cancer, leukemia, lymphoma, or melanoma. The associations between red meat and cancer are summarized in Figure 1 . . .; the figure also shows the null findings for sex-specific cancers, such as . . . |
| Unexpected findings. Red meat seems to help prevent one kind of cancer. | Unexpectedly, red meat intake was inversely associated with endometrial cancer. . . |
| Findings that were relevant only for men in the study. Mention of no difference between women and men for other kinds of cancer. | In further sex-specific analyses, red meat intake was positively associated with pancreatic cancer among men only . . . We observed no differences in risk by sex . . . |
| The pattern of results for red meat intake is repeated again for processed meat intake. Positive, null, and negative results. Lists of types of cancer that fit in each category. Statistical issues for each finding. | **Processed Meat**

[Paragraphs omitted: Similar results for processed meat intake]
[Paragraph omitted: Analysis of risk for more specific types of cancer] |
| An analysis of each variable—red meat and processed meat—independent of the other. Statistical methods for this analysis are mentioned, followed by results. | We conducted sensitivity analyses excluding processed meats from the red meat variable to determine whether the risks associated with red and processed meat are independent of each other. . . The positive associations for red meat and cancer of the liver, esophagus, colorectum, and lung all remain . . . Furthermore, the inverse association for red meat and endometrial cancer remained . . . |
| Remaining interesting statistical details are grouped at the end, to answer any potential concerns the reader may have about the effectiveness of the study. | [Paragraph omitted: Additional statistical analysis showing that results remain significant after controlling for a number of variables.] |

In the following excerpts from the discussion section of the same paper, study results are underlined. Note how the findings mentioned briefly without analysis in the results section are now mentioned again with more analysis and comparison to similar studies. Here, potential limitations of the data are also presented. The results are discussed from strongest proof to weakest. After that, the authors discuss the whole study in general and statistical details and conclude with a clinical application.

Comments	Discussion Section
Topic of the article mentioned first. Note the similarity to the article title. Most significant results also summarized at the beginning of the discussion section. Thus the first paragraph contains no "analysis."	In this large, prospective investigation of red and processed meat intake in relation to cancer risk, **we found elevated risks for colorectal and lung cancer with both meat types. Red, but not processed, meat intake was also associated with increased risk for cancer of the esophagus and liver. We observed borderline statistically significant elevated risks for advanced prostate cancer with both red and processed meat intake, for laryngeal cancer with red meat, and for bladder cancer and myeloma and with processed meat intake.**
The strongest finding from the results section is repeated here, then analyzed. Another review of studies is mentioned. The finding agrees with the previous studies.	**The cancer site most consistently associated with meat intake has been the colorectum**. A recent meta-analysis . . . reported elevated risks in the highest category of consumption of . . . meat [9]. **Our study** included over 5,000 colorectal cancer cases, and it **lends strong support** to implicate red and processed meat as risk factors for this malignancy. **Consistent with previous studies** [9], we observed a stronger positive association for rectal than colon cancer.

Another finding is stated. That this study is the largest of its kind is mentioned. Previous studies are summarized. A potential limitation is mentioned.	**The positive associations for both red and processed meat that we report for lung cancer were of similar magnitude to the findings for colorectal cancer**. To date, our study includes the largest prospective analysis of meat intake and lung cancer risk. Previous case-control studies have reported elevated risks for lung cancer for those in the highest categories of red meat [17–19], fried red meat [8,19], well-done red meat [17], and processed meat intake [20]. Despite conducting analyses to show that very fine control of smoking history, using a 31-level variable, did not attenuate the lung cancer associations, there remains a potential issue of residual confounding by smoking, because it is such a strong risk factor for this disease.
Another finding is presented. Similar studies are mentioned. That this study is the first one with a prospective methodology is emphasized.	**We found a positive association between red meat intake specifically and cancers of the esophagus and liver, and a borderline significant positive association for laryngeal cancer.** The first prospective study of meat intake and esophageal cancer was published recently; that study had only 65 cases and found a positive association for processed meat, but not red meat, with esophageal adenocarcinoma [21]. Our study suggests a threshold effect for red meat intake on esophageal cancer risk, beginning at a low level of intake, with no further increase in risk with higher intakes, as reflected in the p-trend (p = 0.13), although it is possible that the referent group had a smaller-than-expected cancer incidence by chance. Data on meat intake and cancers of the liver and larynx are limited, and our study is the first prospective investigation to report on these associations. Two case-control studies reported elevated risks for laryngeal cancer for those in the highest intake categories of red meat intake [22,23] and fried beef/veal [24].
This paragraph contains only findings and comparison to similar studies. There is a brief mention that there are not many studies of this issue.	**In our study, those in the highest quintile of processed meat intake had borderline statistically significant elevated risks for myeloma,** a malignancy that has not been well-studied for dietary associations, **and bladder cancer.** A study of two prospective cohorts combined [25], and one case-control study [26], both found elevated risks of bladder cancer for those in the highest categories of processed meat consumption, but another cohort study found no association [27].
An unexpected finding is highlighted with the word "unexpectedly" right at the beginning. Because it is unexpected, the authors clearly show that they adjusted the statistics to avoid confounding from other possible causes. However, the authors also cite studies that offer the opposite results.	**Unexpectedly, we found an inverse association between red meat intake and endometrial cancer; this association was not attenuated by adjustment for known risk factors, such as body mass index or menopausal hormone therapy, or by fine control for smoking**, which has been inversely associated with this malignancy [28]. Previous studies have reported null [29,30] or positive relations [31] between red meat and endometrial cancer. We also observed inverse associations between processed meat intake and leukemia and melanoma. In contrast to our findings, childhood leukemia has been positively associated with intake of processed meats in a case-control study [32].
There is quite a bit of research on this finding, so the authors group articles and describe them only briefly. They also offer another potential limitation of their findings.	**Both red and processed meat intake were positively associated with pancreatic cancer in men, but not women.** Red meat has been associated with pancreatic cancer in some [33,34], but not all [35–39] previous cohort studies, as has processed meat in one cohort [34] and several case-control studies [40–44]; although a sex-specific association has not been reported before. Although the association between pancreatic cancer and red or processed meat intake in men was unchanged by fine control for smoking, residual confounding by smoking is still possible.
	[Paragraph on other cancers omitted.]

Previous studies conflict. The authors' results may explain why.	Previous studies of meat intake and prostate cancer are conflicting. Some studies have reported null findings [5,60–66], and others suggest positive associations [67–74]. **Despite finding no association between red or processed meat intake and overall prostate cancer risk, we observed a suggestion of an elevated risk for advanced prostate cancer with both meat types.** If the relation of meat intake to prostate cancer is confined to advanced disease, this could explain some of the inconsistencies in the literature as most previous studies have not specifically addressed advanced prostate cancer.
Although two recent studies have found a breast cancer/red meat connection, the authors did not find one. They speculate why.	With regard to breast cancer, a pooled analysis of eight cohort studies found no association with red meat intake [75]; however, the two most recent prospective studies found positive associations for both red and processed meat [76], specifically for estrogen and progesterone receptor–positive breast cancers in premenopausal women [77]. Although **breast cancer risk related to meat intake did not appear to differ by menopausal status in our study,** we had very few premenopausal cases (n = 94) and lacked information on hormone receptor status for a large number of cases.
	[Paragraph on null cancer risks omitted.]
No more results given. Interpretation of possible reasons for the results. Reasons are based both on understanding of biological mechanisms and on results of other associational studies.	Both red meat, regardless of processing procedure, and processed meat can be linked to carcinogenesis by different mechanisms; for example, they are both sources of saturated fat and iron, which have independently been associated with carcinogenesis. Associations between saturated fat and cancer are likely to be related to energy balance in general, whereas iron is thought to contribute to carcinogenesis specifically by generating free radicals and inducing oxidative stress [94]. Most recently, dietary fat was positively associated with breast cancer [95], and iron intake was positively associated with liver [96] and colorectal cancers [97].
	[Paragraph omitted: More analysis of biological mechanisms for meat/cancer connection.]
The authors suggest reasons for the difference in risk for two types of cancer.	With regard to **the stronger relation of red and processed meat to rectal cancer than to colon cancer,** there is variation in several characteristics along the large intestine. . .
Gap in the research and statistical strengths of study.	Despite abundant biologic pathways linking meat intake to carcinogenesis at numerous anatomic sites, this is the first comprehensive and prospective analysis . . . A particular strength of this study includes the large size of the cohort. . . An additional strength was that our study provid[ed] adequate statistical power to detect associations. Furthermore, recall bias and reverse causation were minimized by . . .
Limitations of the study and why they are not serious.	Potential limitations of this study include some degree of measurement error . . . The energy-adjusted correlation coefficients . . . were . . . These correlations compared very favorably to other . . . Although some measurement error remains, the error associated with . . . tends to result in . . ., and we attempted to minimize this error by . . . [omitted: additional minimizations of error and potential errors].
Conclusion: Main findings repeated again here in the last paragraph. Clinical application of findings.	In conclusion, **a diet high in red or processed meat was associated with an elevated risk of both colorectal and lung cancer; in addition, red meat was associated with an elevated risk of esophageal and liver cancer**. A decrease in the consumption of red and processed meat could reduce the incidence of cancer at multiple sites.

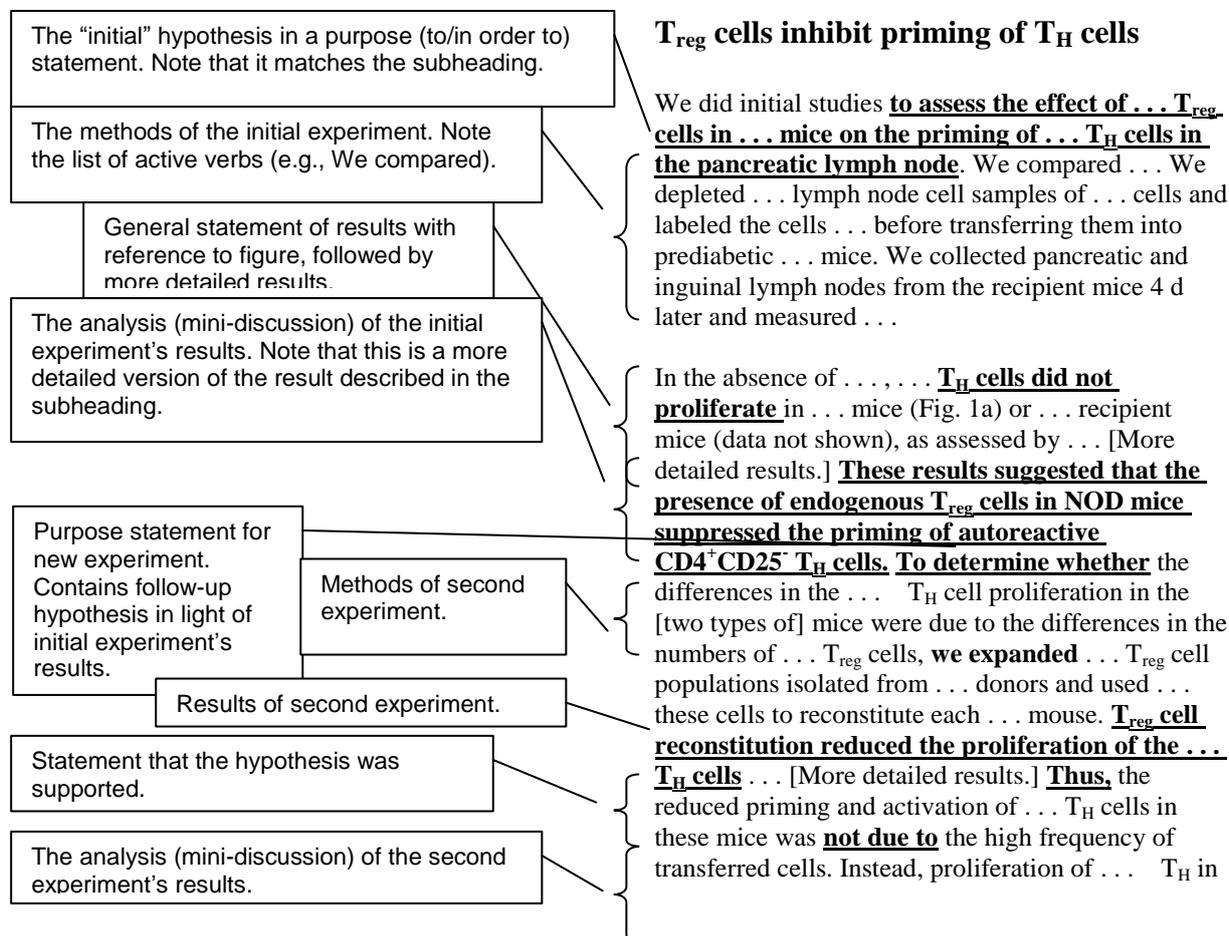## 4.4.2 Results Structure of an Experimental Study in the IRD(m) Format

Here are some observations about the results structure of an experimental study in the field of immunology. Relative to clinical papers, the entire article is quite long. Although not all basic science journals follow the pattern, this journal uses an IRD(m) format. In other words, the article contains a short introduction, followed by longer results and discussion sections. Then there is a separate methods section at the end in small print. Only when necessary for understanding the results, a few concise summary statements about the method are provided in the results section as well, as detailed below. In this paper, out of 10 pages, 7.5 are devoted to the results and discussion.

Tang Q, Adams JY, Tooley AJ. Bi M, Fife BT, Serra P, et al. Visualizing regulatory T cell control of autoimmune responses in nonobese diabetic mice. Nat Immunol. 2006 Jan;7(1):83-92.

The results section of this article is very long and contains several subsections, each with its own subheading. The subheadings denote the main findings:

Subheading	Grammatical Structure
T_{reg} cells inhibit priming of T_H cells	Sentence with active verb
T_{reg} cells alter T_H cell dynamic activity	Sentence with active verb
T_H cell and T_{reg} cell homing	Nouns: this section is a description
Lack of stable T_H cell–T_{reg} cell interactions	Shorter version of "there are no stable . . . interactions
T_H cells and T_{reg} cells interact with DCs	Sentence with active verb

Within each subsection, the authors actually describe several cycles of experimentation. In this particular journal, the summary of each cycle is like a mini-research report, containing a hypothesis, description of methods, main result and more detailed results, and an analysis (discussion) of the result. After explaining one procedure's results, the authors draw a brief conclusion that leads to the next procedure. Note: more often, in other journals it is common not to include the whole cycle. In particular, extra method details and analysis belong in the methods and discussion sections, not in the results section (personal communication, Jeehee Youn).

The "initial" hypothesis in a purpose (to/in order to) statement. Note that it matches the subheading.

The methods of the initial experiment. Note the list of active verbs (e.g., We compared).

General statement of results with reference to figure, followed by more detailed results.

The analysis (mini-discussion) of the initial experiment's results. Note that this is a more detailed version of the result described in the subheading.

Purpose statement for new experiment. Contains follow-up hypothesis in light of initial experiment's results.

Methods of second experiment.

Results of second experiment.

Statement that the hypothesis was supported.

The analysis (mini-discussion) of the second experiment's results.

T_{reg} cells inhibit priming of T_H cells

We did initial studies **to assess the effect of . . . T_{reg} cells in . . . mice on the priming of . . . T_H cells in the pancreatic lymph node**. We compared . . . We depleted . . . lymph node cell samples of . . . cells and labeled the cells . . . before transferring them into prediabetic . . . mice. We collected pancreatic and inguinal lymph nodes from the recipient mice 4 d later and measured . . .

In the absence of . . . , . . . **T_H cells did not proliferate** in . . . mice (Fig. 1a) or . . . recipient mice (data not shown), as assessed by . . . [More detailed results.] **These results suggested that the presence of endogenous T_{reg} cells in NOD mice suppressed the priming of autoreactive $CD4^+CD25^-$ T_H cells. To determine whether** the differences in the . . . T_H cell proliferation in the [two types of] mice were due to the differences in the numbers of . . . T_{reg} cells, **we expanded** . . . T_{reg} cell populations isolated from . . . donors and used . . . these cells to reconstitute each . . . mouse. **T_{reg} cell reconstitution reduced the proliferation of the . . . T_H cells** . . . [More detailed results.] **Thus,** the reduced priming and activation of . . . T_H cells in these mice was **not due to** the high frequency of transferred cells. Instead, proliferation of . . . T_H in

the pancreatic lymph node inversely correlated with the number of T_{reg} cells in these mice.

The excerpt above contains two full cycles of hypothesis-methods-results-analysis. The first cycle is the initial experiment with tentative, general findings.

The second cycle asks why this result was found. The experiment supports the new hypothesis. The subsection continues from there with several more cycles of experiments.

▪▪

The third cycle begins, "Next we determined whether reconstitution of [one type of] T_{reg} cells was more effective than [another type of] T_{reg} cells in inhibiting the priming of BDC2.5 T cells in . . . mice." The third cycle is structured exactly like the first two.

From there, the authors go on to answer more questions about their initial findings to verify that the cause-effect relationship still holds under various conditions. They come to their main conclusion, that T_{reg} cells inhibit priming of TH cells. All the additional subsections of the results section tell the story of experiments that help the authors describe the cause and effect process in more detail.

Again, for each procedure and its results, there is a cycle in the structure of a mini-journal article. Each cycle contains, at minimum, purpose and results. Some also contain an initial review of the literature and/or research question and a very brief description of the method used. In this journal, most also contain a brief interpretation of the results, but generally, further analysis of the results should be saved for the discussion section.

Although the subject is difficult, the results section is basically a story—the story of the experiments and thought processes of the authors from beginning to end. What makes it easier to read is the repetition of the same content structure and grammatical features in the description of each experimental cycle, as shown in the table below.

Sections in the Description of an Experimental Cycle

Part of Experimental Cycle	Language to Signal the Part
Hypothesis in a purpose statement	(In order) to determine . . .
Methods	We did . . .We compared . . .We depleted . . .We collected . . .etc.
Results	We detected . . . We almost never found . . . etc.
Analysis	These results suggested/demonstrated that . . . indicating that . . . Thus . . . etc.

Other features of the authors' particular style also make it easier to read. The subheadings use a present tense verb, which is shortest and easiest to read, but the main text uses the past tense, which more accurately reflects the fact that the experiments happened in the past. In this particular article, figures and tables are always mentioned in parentheses, never in the sentences of the text. These authors also tend to use the active voice for their main procedures, but passive for procedures that are not as central for understanding the context of the whole paper.

Example of Less Central Procedure:

In the absence of islet antigen . . . TH cells did not proliferate in . . . mice **as assessed by** CFSE dilution using flow cytometry.

The authors also make good use of signaling phrases to organize the text.

Examples:

- In fact, . . .
- Moreover, . . .
- In addition, . . .
- Therefore, . . .

- However, . . .
- Furthermore, . . .

4.5 Showing Certainty about Claims

The results and discussion sections of a research report focus on making claims and then adding support for those claims.

4.5.1 What are "Claims"?

1. Statements about your ideas
2. Statements about your data
3. Statements about other people's ideas and data

In other words, "claim" is a very general word, and there are many claims in a single journal article.

Here is an example of a claim.

Example:

Basic claim: An increase in smoking among teenagers caused long-term health problems.

When the proof of your idea or data is clear, you should strengthen your claim. When the evidence is less certain, you should limit or weaken your claim. Below are some examples of strengthening and limiting the example above.

Examples of Stronger Claims:

An increase →   A sharp increase
caused → undeniably caused, clearly caused, undoubtedly caused, must have caused, etc.
long-term health problems → widespread long-term health problems

You could also add expressions to the beginning of the sentence:

It is clear that an increase . . .
A great deal of evidence leads us to conclude that an increase . . .
We must conclude that an increase . . .

Examples of Limited Claims:

An increase → a probable increase
caused → may have caused, seemed to have caused, contributed to, was one cause of, etc.

Again, you could also add expressions to the beginning of the sentence:

We have reason to believe that an increase . . .
It is possible that an increase . . .

Below is a longer list of expressions from Hyland (2004) that strengthen or limit claims. Note that they have a range of meanings, both positive and negative, so choose carefully after looking at several examples from Google Scholar or other published papers.

Hyland, K. Disciplinary Discourses: Social Interactions in Academic Writing. Ann Arbor: U of Michigan; 2004. p. 192.

4.5.2 Expressions for Strengthening a Claim

Nouns
certainty
evidence
the fact that
(without) question

Adjectives
assured
certain that
clear
conclusive
is essential
impossible
improbable
inevitable
least
more than
obvious
plain
precise
reliable
sure
true
unambiguous
undeniable

undoubted
unequivocal
unmistakable
unquestionable
well-known

Verbs
conclude
confirm
convince
demonstrate
determine
expect
we find
we know
it is known that/to
perceive
prove
show
surmise
we think

Modals
could not
must

will
will not
would not

Adverbs
actually
always
assured(ly)
at least
certainly
clear(ly)
conclusive(ly)
convincingly
decided(ly)
definite(ly)
impossibly
improbably
manifest(ly)
more than
necessarily
never
obvious(ly)
particularly
patently
plain(ly)

precise(ly)
quite
reliable/reliably
sure(ly)
unambiguous(ly)
unarguably
undeniably
undoubted(ly)
unequivocal(ly)
unmistakably
unquestionably
wrong(ly)
right(ly)

Interjections
of course
doubtless
in fact
indeed
no doubt

Transition
given that

4.5.3 Expressions for Limiting a Claim

Adverbs
admittedly
almost
(not) always
apparently
approximately
basically
conceivable/conceivably
essentially
evidently
formally
frequently
(in) general
generally
hypothetical(ly)
ideally
largely
likely
mainly
maybe
more or less
not necessarily
normally
occasional(ly)
often
ostensibly
partly

partially
perhaps
possible/possibly
predominant(ly)
presumable/presumably
probable/probably
quite
rare(ly)
rather
relatively
seemingly
seldom
somewhat
sometimes
superficially
technically
in theory
theoretically
typically
unlikely
usually
virtually

Verbs
appear
argue
assume

believe
claim
deduce
discern
doubt
estimate
guess
hypothesize
(we) imagine
imply
indicate
infer
interpret
perceive
postulate
predict
presume
propose
seen (as)
seem
speculate
suggest
suppose
surmise
suspect
tend

Modals
could
may
might
should
should not
would

Nouns
assumption
our belief
certain extent
conjecture
contention
implication
possibility
prediction
probability
(general) sense
tendency

Adjectives
about
a certain [noun]
around
consistent with
most
open to question
plausible
questionable
uncertain
unclear
unsure

Transition
provided that

4.5.4 Study Limitations

Near the end of the discussion section of your journal article, you should include a paragraph or two addressing the limitations of your study. This is particularly critical in clinical studies, where not acknowledging limitations could lead clinicians to apply your findings before they have been adequately investigated. Here are some examples adapted from Swales of expressions for limiting claims in the discussion section.

Expressions for limitations of the study:

- It should be noted that this study has been **primarily** concerned with . . .
- This analysis has **concentrated on** . . .
- The findings of this study are **restricted to** . . .
- This study has addressed **only** the question of . . .
- The **limitations** of this study **are clear** . . .
- We would like to point out that **we have not** . . .

Expressions for stating conclusions that should NOT be drawn:

- However, the findings **do not imply**
- The results of this study **cannot be taken as evidence** for . . .
- Unfortunately, we are **unable to determine** from this data . . .
- The **lack of** . . . means that we **cannot be certain** . . .

Expressions for very limited studies:

- **Notwithstanding** its **limitations**, this study **does suggest** . . .
- **Despite** its **preliminary** character, the research reported here **would seem to indicate** . . .
- **However exploratory**, this study **may offer some insight** into . . .

4.5.5 Using modals to strengthen or limit a claim

One of the groups of words in each of the two lists above is modals. Modals (can, may, could, etc.) can strengthen or limit a claim. In fact, modals are probably the most common way to show degree of certainty. However, they are very difficult to define for English learners. There is no exact translation among different languages. Here is a more detailed description of the modals. More examples follow later in this chapter.

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	Description	Examples
Past and present: no modal. Just a regular verb **Future: WILL**	Giving generalizations: statements that people in the field generally agree on OR Citations: Summarize the findings of others (report, describe, demonstrate, show, prove, etc.). OR Reporting certain results: May be proven mathematically. (Rare in biomedical science.) AND Predictions: No or little doubt about the future.	**Generalization:** 1. Prevalence of mixed depression, a combination of depression and manic or hypomanic symptoms, **is** high in patients with bipolar disorders. Benazzi F. Bipolar disorder—focus on bipolar II disorder and mixed depression. Lancet. 2007 Mar 17;369(9565):935-45. **Citation:** 2. Genetic studies[11] **show** high heritability of the trait, and segregation analysis suggests the presence of an autosomal codominant major gene conferring susceptibility to podoconiosis. Davey G, Newport M. Podoconiosis: The most neglected tropical disease? Lancet. 2007 Mar 17;369(9565):888-9. **Prediction:** 3. Those likely to be sick will face ever increasing premiums, and voluntary coverage **will** continue to decline. Luft HS. Universal health care coverage: a potential hybrid solution. JAMA. 2007 Mar 14;297(10):1115-8.
CAN	Possibility: It is possible, but will not happen every time. OR Ability	**Possibility:** 1. Recent studies [3,4,36–38] have shown that therapeutic hypothermia **can** result in better outcomes for patients with out-of-hospital ventricular fibrillation. SOS-KANTO study group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. Lancet. 2007 Mar 17;369(9565):920-6. **Ability:** 2. How **can** we explain the discrepancy between studies of mite avoidance in children that suggest some benefit [6,8,17] and the data from our study and other studies involving adults that show no improvement in asthma control? [5,10,21] Woodcock A, Forster L, Matthews E, Martin J, Letley L, Vickers M, et al. Control of exposure to mite allergen and allergen-impermeable bed covers for adults with asthma. N Engl J Med. 2003 Jul 17;349(3):225-36.
WOULD	Limited by a condition: Often used with an "if" subordinate clause that describes the condition. (The "if" clause is usually unstated when it is clear from the context.)	**Limited by a condition:** 1. This fundamental restructuring of the payment system **would** achieve both universal coverage and improved efficiency [if . . .]. Lurie N, Dubowitz T. Health Disparities and Access to Health. JAMA. 2007 Mar 14;297(10):1118-21. 2. [If . . .] the best impetus for change **would** result

		not from litigation, regulation, or other outside forces, but from within the health care system. Kirschner KL, Breslin ML, Iezzoni LI. Structural Impairments That Limit Access to Health Care for Patients With Disabilities. JAMA. 2007 Mar 14;297(10):1121-5.
	Other uses: "We would (like to) [reporting verb]. . ." This is a special expression that allows you to use reporting verbs for yourself.	**Using a reporting verb with "we":** 3. We **would** like to emphasize that we cannot prove whether the measured antimyelin antibodies in our patients are antibodies with demyelinating capacity or whether they represent an epiphenomenon of myelin destruction. Berger T, Rubner P, Schautzer F, Egg R, Ulmer H, Mayringer I, et al. Antimyelin antibodies as a predictor of clinically definite multiple sclerosis after a first demyelinating event. N Engl J Med. 2003 Jul 10;349(2):139-45.
	OR	4. . . . we **would** recommend the use of a technique including predilation with shorter balloons, the use of longer single stents in order to cover the entire zone of balloon injury, . . . Moses JW, Leon MB, Popma JJ, Fitzgerald PJ, Holmes DR, O'Shaughnessy C, et al. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. N Engl J Med. 2003 Oct 2;349(14):1315-23.
	Past tense of WILL	5. Our hypothesis was that high-intensity warfarin **would** be more effective than moderate-intensity therapy. Crowther MA, Ginsberg JS, Julian J, Denburg J, Hirsh J, Douketis J, et al. A comparison of two intensities of warfarin for the prevention of recurrent thrombosis in patients with the antiphospholipid antibody syndrome. N Engl J Med. 2003 Sep 18;349(12):1133-8.
SHOULD	Reasonable expectation (more than 50%) OR Stating limitations indirectly (a "recommendation" to oneself) Other Uses: Making recommendations about future studies or clinical treatment	**Reasonable expectation:** 1. D-Dimer is a marker of endogenous fibrinolysis and **should** therefore be detectable in patients with deep-vein thrombosis. Wells PS, Anderson DR, Rodger M, Forgie M, Kearon C, Dreyer J, et al. Evaluation of D-dimer in the diagnosis of suspected deep-vein thrombosis. N Engl J Med. 2003 Sep 25;349(13):1227-35. **Stating limitations indirectly:** 2. Potential limitations of our study **should** be acknowledged. **Recommendation about future studies:** 3. Further analysis of these mice **should** more clearly define the contribution of SDF1 in this setting and, more globally, to the nonredundant roles for RBP2 demethylase activity in vivo. Klose RJ, Yan Q, Tothova Z, Yamane K, Erdjument-Bromage H, Tempst P, et al. The retinoblastoma binding protein RBP2 is an H3K4 demethylase. Cell. 2007 Mar 9;128(5):889-900.

		Recommendations about clinical treatment:
		4. … the decision to perform ablation **should** also take into account the risk of a fatal complication. Pappone C, Santinelli V, Manguso F, Augello G, Santinelli O, Vicedomini G, et al. A randomized study of prophylactic catheter ablation in asymptomatic patients with the Wolff-Parkinson-White syndrome. N Engl J Med. 2003 Nov 6;349(19):1803-11. 5. Both generalists and medical subspecialists **should** recommend influenza vaccinations to their elderly and high-risk patients. Nichol KL, Nordin J, Mullooly J, Lask R, Fillbrandt K, Iwane M. Influenza vaccination and reduction in hospitalizations for cardiac disease and stroke among the elderly. N Engl J Med. 2003 Apr 3;348(14):1322-32.
MAY	Possibility (some doubt): Very common for reporting results cautiously.	**Possibility:** 1. The cohort study had a small number of participants, unaccounted crossover between the groups, and large loss to follow-up, which **may** have affected the validity of the results. Sambunjak D, Straus SE, Marušić A. Mentoring in academic medicine: A systematic review. JAMA. 2006 Sep 6;296(9):1103-15.
COULD	Possibility (more doubt): More cautious than CAN Common with "whether" Other Uses: Past tense of CAN	**Possibility:** 1. It is possible that the presence of these mutant p53 proteins in human tumors **could** negatively affect the outcome of functional p53 restoration depending on how p53 function is restored. Kastan MB. Wild-Type p53: Tumors Can't Stand It. Cell. 2007 Mar 9;128(5):837-40. **With "whether":** 2. It remains to be determined **whether** mutations in *MC4R* **could** be one cause of long-term treatment failure. Branson R, Potoczna N, Kral JG, Lentes KU, Hoehe MR, Horber FF. Binge eating as a major phenotype of melanocortin 4 receptor gene mutations. N Engl J Med. 2003 Mar 20;348(12):1096-103. **Past tense of "can":** 3. Patients were contacted by telephone every 7 to 14 days so that investigators **could** monitor compliance and safety. Rowbotham MC, Twilling L, Davies PS, Reisner L, Taylor K, Mohr D. Oral opioid therapy for chronic peripheral and central neuropathic pain. N Engl J Med. 2003 Mar 27;348(13):1223-32.
MIGHT	Possibility: Same strength as COULD	**Possibility:** 1. Reactive T cells **might** produce higher levels of interleukin 5, stimulating tissue cosinophilia and subsequent pruritus.

Byrd JA, Scherschun L, Chaffins ML, Fivenson DP. Eosinophilic dermatosis of myeloproliferative disease: Characterization of a unique eruption in patients with hematologic disorders. Arch Dermatol. 2001 Oct;137(10):1378-80.

4.5.6 Strength of Claim
Examples in Context

As Turner has noted,

> Generally those fields that have fewer variables or variables that can be controlled in the laboratory or tested or simulated mathematically are much more likely to use the present tense to give their conclusions. Those fields . . . involving human beings or natural process that are hard to isolate in life sciences and medicine are more likely to use model forms (may, etc.) to discuss results.

Thus research reports in biomedical engineering and bioinformatics, for example, will often contain stronger claims than, for example, clinical psychology. The best way to choose the right forms for your own writing is to emulate good writers in your own field. Try searching a collection of PDF files of published articles for modals and the other expressions listed above. Observe how each is used in context, just as the following discussion section is analyzed below.

In the following excerpts from a discussion section, the expressions for strength of claim are underlined. Note that some are exact statistical statements (e.g. significant), and others are more vague (e.g. nearly all). Also note that the authors tend to use different expressions in each part of the discussion section.

The article tested the benefits of providing children under 4 years old with zinc dietary supplements. The first excerpt comes from the very beginning of the discussion section, where the authors summarize the findings they have already presented in the results section. They use a variety of expressions to show the strength or weakness of each claim.

Sazawal S, Black RE, Ramsan M, Chwaya HM, Dutta A, Dhingra U, et al. Effect of zinc supplementation on mortality in children aged 1–48 months: a community-based randomised placebo controlled trial. Lancet. 2007 Mar 17;369(9565):927-34.

Example:

In our study, zinc supplementation did not result in a **<u>significant</u>** reduction in **<u>overall</u>** mortality in children aged 1–48 months in a population with high malaria transmission. However, **<u>there was a suggestion that</u>** the effect varied by age, with no effect on mortality in infants, and a **<u>marginally significant</u>** 18% reduction of mortality in children 12–48 months of age ($p=0\cdot045$). This effect was **<u>mainly</u>** a consequence of fewer deaths from malaria and other infections. Any effect on mortality in this trial was in addition to a **<u>possible</u>** effect of vitamin A supplementation . . .

The second excerpt suggests several possible interpretations of one result, that zinc supplements did not have a measurable affect on infants less than 1 year old. Note that the authors use "might" and "could" frequently and alternate the two expressions for variety. The discussion is framed at the beginning and end with two other expressions: possible and suggest(ion).

Example:

There are several **possible** explanations for the absence of effects of zinc supplementation in children younger than 12 months. Infants **might** have acquired adequate zinc in utero . . . Alternatively, the absence of effect in this age group **might** be related to the low 5 mg dose used. . . Effects of zinc **might** be mediated through improvement in immunity . . . and this effect **could** be restricted in infants . . . [V]ariation in response to zinc supplements in infants in different populations **might** be expected. Our findings of no effect in infants need further investigation . . . because they **could** have important implications for targeting of children who would benefit from additional zinc. . . Nutritional and immunological differences **might** affect responses to infections and survival. . . Thus, the results of this large community-based placebo controlled zinc supplementation trial **suggest** that . . . zinc supplementation did not have any effect on mortality in infants, but there **was a suggestion of** reduced mortality in children older than 1 year.

The last section of the discussion offers suggestions for future research. Note the use of "would" in the suggested hypothesis statement. This is a rewritten version of the Yes/No question: "Would a higher dose have a different effect?" As usual, "would" is combined with an implied "if." "If we did another study, would a higher dose. . .?" For more information on how to write research questions, see the Introductions chapter.

Example:

Feasible and sustainable methods of enhancing the bioavailable intake of dietary zinc need assessment. We also need to know whether a higher dose **would** have a different effect in infants, and to elucidate the mechanisms of the effects of zinc and any differences between boys and girls. Our results **suggest** a need for meta-analysis of all available studies both for mortality and morbidity to make evidence based recommendation for public health policy to improve mortality, morbidity, growth, and development.

Sazawal S, Black RE, Ramsan M, Chwaya HM, Dutta A, Dhingra U, et al. Effect of zinc supplementation on mortality in children aged 1–48 months: a community-based randomised placebo controlled trial. Lancet. 2007 Mar 17;369(9565):927-34.

4.6 Recommended Reading

See Chapter 4 of the textbook *Academic Writing for Graduate Students* for more detailed advice on modifying the strength of claims. Although the book is directed at graduate students, there are also a number of grammar and style tips on other topics that would be helpful even to those who have already earned their degrees.

Swales JM, Feak CB. *Academic Writing for Graduate Students, 2nd ed.* Ann Arbor: U of Michigan; 2004.

4.7 Checklists for Evaluating Your Writing

The following two checklists are excerpted from Adam Turner's *English Solutions for Engineering Research Writing* (2006). Although they were originally written for evaluating engineering journal articles, all the points are relevant to biomedical research writing.

4.7.1 Results Section Checklist

1. I do not merely describe all of the results, but interpret the important results for the reader. I use words like "significant, moderate, unexpectedly, surprisingly and interestingly," to interpret the results and not just give a list of results.
2. If appropriate, I have pointed out any problems or inconsistencies with the data (not the
3. same as limitations of the paper).
4. If my results are statistical, I have done all the necessary tests to determine the validity of the results.
5. If my paper does not have a separate "Discussion" section, I have included references that compare my findings with the results in previous research papers.

6. I have used the past tense to talk about the specific results of my paper but I have used the present tense to talk about descriptions of figures or tables and generalizations based on my results of general statements about my whole field.
7. My tables have titles on the top but my figures have captions on the bottom.   ☐

4.7.2 Discussion/Conclusion Section Checklist

1. I discuss only the most significant findings and do not simply repeat the results section with more commentary.
2. I have noted any problems with the methods or data. I note the implications of these problems and how they might affect the validity of my conclusions.
3. My discussion section includes references from other papers to either support or compare my research.
4. I have explained why my results differ from previous research if applicable.
5. I have analyzed the structure of papers in my field to understand the relationship between the results, discussion and conclusion sections.
6. I have identified and clearly explained the importance of the findings for the field as a whole.
7. I have mentioned whether my results support or differ from previous research in the field. If they differ, I have attempted to explain why.
8. I have mentioned some possible areas for further research, the importance of the findings or the implications and possible applications of the research (not all are required in all fields).