# Lecture 6
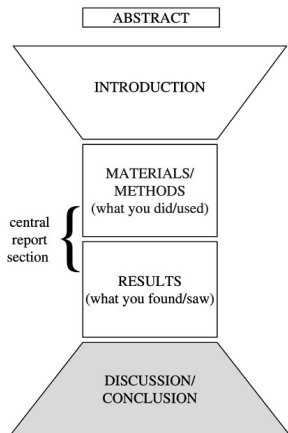# Writing the Discussions Section of a Paper

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October 19, 2023

# What is the discussions section for?

The discussions section should provide the answer to one simple question:
**What do the results mean?**

## Elements of the discussions

The discussions section may contain the following elements:

- Present summary of your findings and how the findings address the hypothesis or questions posed in the introduction;
- Explain why the findings occurred;
- Show how the results agree with or differ from previous work;
- Discuss the significance of the results;
- Discuss the implications of the results;
- Present limitations of your work;
- Provide take-home messages or future research directions.

## Things to avoid in the discussions

In the discussions section, you generally should not:

- excessively repeat the results;
- introduce new results that have never been mentioned before;
- pretend to have solved everything;
- finish with vague and throwaway sentences;
- attempt to discuss every possibility, especially if speculative.

# General structure of the discussions section

Discussion can be divided into subsections, each dealing with a particular aspect of the findings.

Discussion can start with a brief reiteration of research question or major findings and usually ends with a concluding remark.
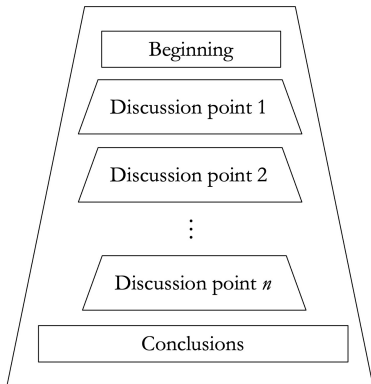
## How to start the discussion

One strategy to start the discussion is to summarize the main findings of the work. This is particularly useful when there are one or few major points of findings to discuss;

> The results presented here show that long-term average weathering-derived solute concentrations vary from catchment to catchment as a function of mean funoff and that on timescales shorter than several years, these solute concentrations in individual catchments vary little from their long-term averages, even during floods or droughts. The average concentration for a given site and solute can be thought of as a chemical set point, around which geochemical feedbacks act to maintain approximate equilibrium. Expressed in this terminology, the main result presented above is that weathering-derived solute concentrations tend to be quasi-chemostatic, but their set points may vary from catchment to catchment as a function of mean runoff.

(Godsey et al 2019, Hydrological Processes)

## How to start the discussion

When providing a summary of your findings, you could point out whether the hypothesis were supported or not. This is an effective strategy when your introduction has very clearly stated hypothesis that motivates the work;

The results of this study showed consistent support for the hypothesis that $V_{max}$ and $K_m$ are temperature sensitive for soil microbial extracellular hydrolytic enzymes (EHEs). Our hypothesis that cold-adapted EHEs would show greater temperature sensitivity for $K_m$ than warm-adapted EHEs was only supported for the cellulose-degrading enzyme $\beta-$glucosidase. No clear patterns were observed for the four other EHEs investigated. To our knowledge, this is only the second study to examine the temperature sensitivity of $K_m$ in soil EHEs, and in the other, Stone et al. (2012) also observed more variation in the $K_m$ response to temperature than in the $V_{max}$ response.

(German et al 2012, Global Change Biology)

# How to start the discussion

You can also begin the discussion by reiterating the background and/or significance of the work.

> Nonindependence among observed effect sizes from the same source paper is common in ecological meta-analyses and can arise through a variety of mechanisms, such as shared experimental subjects, common experimental sites, or similar methodology. The variety of mechanisms leading to within-paper non-independence gives rise to different patterns and strength of correlations among observed effect sizes from the same source paper. Our simulations, using ecological realistic parameter values, represent a broad range of scenarios. We found that...

(Song et al 2020, Ecology)

# Structure of each discussion point

**OCAR strategy**: reiterating the problem and reenergizing curiosity before going on the nailing down the answer with the resolution.

It is well-known that factors such as the nature of the nucleophile, solvent, and leaving group directly affect the rate of the bimolecular nucleophilic substitution (SN2) reactions; yet, in the case of carbanions, little has been documented with absolute rate constants...

Photoinduced decarboxylation of suitable substituted carbanions provides a route for the formation of substituted cycloalkanes that proceeds in high yields in nonhydroxylic solvents and with good leaving groups such as bromide and iodide.

(Llauger et al 2004, Journal of Organic Chemistry)

# Structure of each discussion point

**LD strategy**: identify the main contribution/finding of the paper and then develops and elaborates the finding. This is the most common strategy when writing each discussion subsection.

> We have identified a novel class of GGT inhibitors that are not glutamine analogues. Kinetic studies of the lead compound OU749 revealed that the mechanism of inhibition was uncompetitive relative to the $\gamma-$glutamyl substrate, indicating that the inhibitor bound the enzyme-substrate complex.

## What to discuss: put your work in context

How do your findings compare with existing work/theory?

- Discussing how your findings confirm or contradict previous work is an effective way to put your work in context.

- This lends support/credibility to your findings (if consistent) or gives you an opportunity to explain your findings (if inconsistent).

- This may also give you an opportunity to highlight how your work improves previous work, i.e., the implications of your work.

Why did the findings occur? When explaining your findings, relate your speculation to concrete evidence from your study or previous work. Pure speculation without evidence is not very convincing.

The important role of consumers in explaining our results is supported by previous research at our study sites. Small forest streams at Coweeta (North Carolina, USA) are extremely retentive of CPOM, their primary OM source. CPOM exports from the reference and treatment streams are typically 2.5% of CPOM inputs and 4% of total OM export (Cuffney et al. 1990, Wallace et al. 1995). Particulate OM export is consequently dominated by suspended FPOM (Wallace et al. 1991). Although peak FPOM export coincides with storms, manipulations of invertebrate biomass have showed that the role of invertebrate feeding activity (especially by shredding detritivores) is at least as important as discharge in controlling the magnitude of FPOM export from these headwater stream ecosystems (Cuffney and Wallace 1989, Wallace et al. 1991).

(Benstead et al 2009, Ecology)

## What to discuss: implications

Discussing the implications is usually a necessary part of the discussion. It answers the question: "**so what?**"

What is considered the implications of your work?

- Does it extend or supplement previous work?
- Does it deepen our understanding of a scientific question?
- Does it challenge or confirm a theory?
- Does it solve an existing problem?
- Does it offer a novel prediction about a phenomenon?
- Does it inform us about new or improved methodologies?

**Example**: how the current findings help us form new predictions.

> We observed strong and consistent seasonal decreases in BDOC, potentially due to the fact that changes in thaw depth are more pronounced in warm permafrost regions such as the Qinghai-Tibetan Plateau (QTP). In contrast to the Arctic catchments with 20–50 cm of seasonally thawed soil, QTP flow paths can penetrate to over a meter by the end of the flow season. This provide a potential analogue for predicted Arctic and Boreal conditions in 50 to 100 years, suggesting that increasing active layer depth could decrease DOC export and biodegradability, though more work is needed to constrain the predictions of lateral carbon transport.

(Mu et al 2017, Geophysical Research Letters)

# What to discuss: implications

**Example**: how the findings extend previous work, deepen the understanding of a phenomenon, and test an existing theory.

GPP increased with temperature across catchment with a temperature dependence equal to another recent study on metabolism in geothermal streams (Demars et al. 2016), but it did so because biomass also positively covaried with temperature. This is likely driven by...After accounting for covariance with biomass, biomass-specific GPP was independent of temperature, consistent with the effects of temperature compensation of organism-level metabolism. These findings confirm the predictions of our model and previous suggestions (Kerkhoff et al. 2005. Enquist et al. 2007) that local adaptation and species sorting can yield the paradoxical phenomenon that rates of biomass-specific ecosystem metabolism are independent of temperature over thermal gradients that have been maintained over long timescales.

(Padfield et al 2017, Ecology Letters)
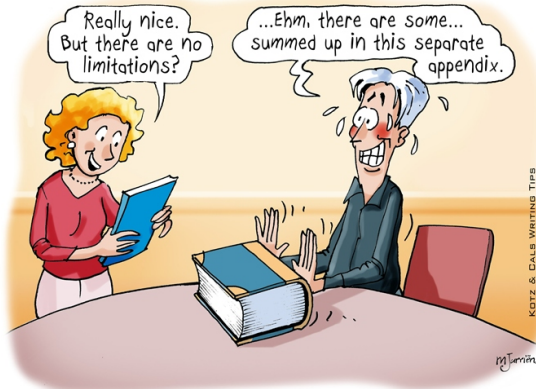
# What to discuss: limitations

What are the limitations of your work?

- This can be a few sentences in the section where you discuss a particular point, or you can dedicate a separate section for it;

- Limitation should be short and concise; Avoid putting limitations at powerful positions, i.e., opening or end of the section.

- Only discuss limitations critical for the interpretation or applicability of your study;

- Common issues causing limitations: unique study settings that lead to lack of generality; limited sample size, study sites, or study duration; potential artifacts due to instruments/methods.

# What to discuss: limitations

It is usually most effective to address limitations immediately after a particular discussion point.



Tip 6 – Discussion: be frank in acknowledging limitations!

# What to discuss: limitations

In this example, the discussion of limitation comes right after the relevant discussion point; but the discussion does not end with limitation. Rather, it ends with statements about the significance of the finding.

We quantified warming-induced changes in NEP, the difference between GPP and ER, based on the simulated warming experiment. We estimated that a 1 °C increase in temperature will increase GPP from 0.89 to 1.12 g $O_2$ $m^{-2}$ $day^{-1}$, and ER...

The prediction for how GPP/ER and NEP will change with warming do not come without caveats...Despite these caveats, our prediction are based on findings from streams that encompass a broad range of biotic and abiotic conditions, which provide a robust basis for assessing the effects of warming on stream metabolic balance across the globe.

(Song et al 2018, Nature Geoscience)

# Tying it all together: a simple model for discussion

Putting the above elements of discussions together, we may put together a generic template for discussion.

A template can be useful for beginner, but as you become more experienced, I do not recommended following the same template religiously.

Our experiment demonstrated that_____. In particular, we found that_____. Our findings are consistent/in contrast with previous work. For example, _____was found to_____. We speculate that_____may be responsible for the observed consistency/contradiction. Such a speculation is supported by previous work where_____may explain_____. Taken together, these results mean that_____. We therefore suggest that_____.

# Conclusions

Conclusions usually start with a concise summary of major findings and end with the implications of your work or guidance for future work. It should be concrete and have close link to the major findings of the current work.

There was an extraordinarily large amount of ice bottom melting in the Beaufort Sea region in the summer of 2007. Solar radiation absorbed in the upper ocean provided more than adequate heat for this melting. An increase in the open water fraction resulted in a 500% positive anomaly in solar heat input to the upper ocean, triggering an ice-albedo feedback and contributing to the accelerating ice retreat. The melting in the Beaufort Sea has elements of a classic ice-albedo feedback signature: more open water leads to more solar heat absorbed, which results in more melting and more open water. The positive ice-albedo feedback can accelerate the observed reduction in Arctic sea ice. Questions remain regarding how widespread this extreme bottom melting was, what initially triggered the increase in area of open water, and what the summer of 2007 portends for 2008 and beyond.

(Perovich et al 2008, Geophysical Research Letters)

# Avoid weak conclusions

A weak conclusion fails to clarify the take-home message and gives a vague statement about the implications of the work. Avoid using vague and empty statements like "provide new insights" or "have profound implications" without clarifying what they are.

A proteomic evaluation of hummingbirds under simulated migratory conditions revealed evidence of several stress-associated processes: protein degradation in wing muscle tissues, depletion of metabolic cofactors, and enhancement of stress-response proteins. These results suggest that changes in the hummingbird proteome may provide new insights into the complex physiology of avian systems biology

# Do not undermine your conclusions

Avoid undermining your own conclusions. Conclusions should emphasize the value of the work. While it is necessary to admit limitation, do not end with it.

> To conclude, 3-methyl-ambrosia offers a new approach for thyroid carcinoma therapy. Our data provide evidence on safety and *in vivo* activity of this compound in patients with this condition, although the proof for clinical benefit remains to be established in future clinical trials.

The conclusion can be improved by simply switching the order of the sentences. This helps put the emphasis on the contributions of the work.

> While further clinical trials will be necessary to establish the full benefits of 3-methyl-ambrosia as a therapeutic agent, our data provide evidence that it is safe and shows *in vivo* activity against thyroid tumors. 3-methyl-ambrosia therefore may offer a new approach for treating patients with thyroid carcinoma.

# Writing style: tense

The tense of the discussion section may switch between present tense (when mentioning established knowledge or general principles) and past tense (when mentioning your own results or previous studies).

Despite the consistency of this average result with predictions of the MTE and with findings from other studies at the global scale, we observed a large degree of variation in E among individual streams. Slight differences in the value of this slope can translate to substantial differences in respiration rate. For example, the E values that we estimated for individual tributaries spanned the entire range included in a recent global meta-analysis of temperature sensitivities in rivers and streams. In fact, the only other study to evaluate the variation in temperature sensitivity among individual tributaries at the river basin scale also found a similar magnitude of variation. Taken together, these data suggest that using a universal value to describe the temperature sensitivity of C processing across a river basin does not accurately reflect the variation in C metabolism that occurs as rivers drain heterogeneous landscapes with spatial variation in geomorphic and chemical conditions.

(Jankowski et al 2014, Ecology)

# Writing style: modal verb

Modal verbs are often used in the discussions to communicate that something is a possible reason or a probably interpretation.

Compare the different amount of "certainty" conveyed in the following three sentences:

The drop in pressure **was** due to a crack in the pipe.
The drop in pressure **must have been** due to a crack in the pipe.
The drop in pressure **may have been** due to a crack in the pipe.

## Writing style: verb choice and strength of claim

The choice of verb carry much of the meaning about attitude of findings or strength of claim. In the example below, the choice of verb goes from strong and confident claims to weak and uncertain claims.

Our experimental results **demonstrate** that_____.
Our experimental results **mean** that_____.
Our experimental results **indicate** that_____.
Our experimental results **suggest** that_____.

## Writing style: metacommentary

Metacommentary is a way of commenting on your claims and telling others how—and how not—to think about them.

- Because the written word can be interpreted in many different ways, we need metacommentary to keep misinterpretations and other communication misfires at bay.
- Metacommentary adds clarity and depth to the writing. It helps you avoid misunderstanding, elaborate ideas, or preemptively address objections.

Avoid misunderstanding:

We do not suggest that_____, but that_____.
This does not mean that_____, but rather_____.
_____is concerned less with_____ than with_____.

Elaborate ideas:

In other words, _____.
To put it another way, _____.
What_____suggest here is that_____.

Address potential objections:

Although one may object that_____, we argue that_____.