

# Writing Papers in Biology

For General Biology I (BIOL 1111)

Adapted from "Scientific Writing and Communication" taught by Dr. THEODORE W. PIETSCH at School of Aquatic and Fishery Sciences, College of The Environment, University of Washington

## Why this lab unit comes about?

1. A realization by faculty and lab instructors in the Biological Sciences that undergraduates, especially as freshmen and sophomores, need help with writing scientifically.
2. A realization also that a course in scientific writing, especially as it relates to the biological sciences is lacking on campus or in the department.
3. A realization that students commit plagiarism due to lack of knowledge on scientific writing.

## What are goals of this lab unit?

- The lab unit is designed to teach undergraduates in the Dept. of Biological Sciences, especially in BIOL 1111 class to:
  1. Critically read scientific writing;
  2. Access electronic sources of information, including but not limited to internet searches, library databases, and public data;
  3. Learn the structure and functions of different components of scientific papers to effectively communicate scientific findings; and
  4. Understand the ethical boundaries associated with scientific communication.

## The textbook, and use thereof:

- McMillan, Victoria E. 2012. *Writing Papers in the Biological Sciences*, 5th Edition. Bedford/St. Martin's Press, Boston
- OR
- Knisely Karin. 2013 *A Student Handbook for Writing in Biology*, 4th Edition. W. H. Freeman Publishers

Not required to purchase; but, recommended to have a copy of a writing manual because:

- Required in upper level course(s).
- Reference book to improve your writing skill throughout your college years.
- This presentation does not cover every detail in the book.

## The structure of a scientific paper: How to write one and how to read one

The structure and function of the major subunits of the main body of a scientific paper.

A scientific paper is really three (3) separate papers. This fact is critically important when you set out to write a paper, or to read one.

**Title: Fishing for readers**

**Abstract: The “Reader’s Digest” version**

**The body of the paper: The whole story**

- Although, in published form, the title comes first and the abstract second, they are nearly always the last to be written, or at least the last items to be finalized.
- The body of the paper is tackled first.

## The body of a paper in a typical journal:

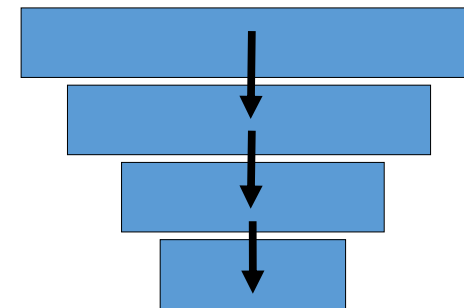
- Introduction
- Materials and Methods
- Results
  - Text
  - Tables
  - Figures
- Discussion
- Acknowledgments
- Literature Cited

**A number of journals, including some highly prestigious ones like *Science and Nature*, have very different formats, but we’ll focus on the standard format used by the vast majority of journals.**

Often referred to as “IMRAD” format: Introduction, M & M, Results and Discussion.

## The Structure of Introduction

- Begin with the broadest scope and get progressively narrower, leading steadily to the statement of objectives in the last sentence or paragraph of the Introduction.



## The Structure of Introduction

- Statement of objectives:  
The key to the whole paper

The last sentence or last paragraph of the introduction needs to **flow from** the rest of the **introduction** and **transition to** the description of the **materials and methods**. It is critical that the goals and objectives be stated clearly and, if applicable, stated quantitatively.

## An example of “Objectives”:

- Not so good:  
The purpose of this study is to see if there is a difference in the fish in three parts of the stream.
- Much better:  
The overall goal of the study was to test the hypothesis that habitat complexity was positively correlated with fish species diversity and density. Specifically, we sampled the fish community and physical features in two habitat units in each of three reaches of stream and also measured the micro-habitat features where fish were caught. These data were used to. . . .

## Materials and Methods

- Description of what was needed to do the work (e.g., specimens), what was done, and how it was done, when and where (if these are necessary details).
- Not a narrative, as you might write to your friend describing your day (“First we drove the van to the river, then we launched the boat and. . .”) but rather a concise description of what a reader would need to envision, understand, assess, and (if needed) replicate the work.

## An example of “Methods and Materials”:

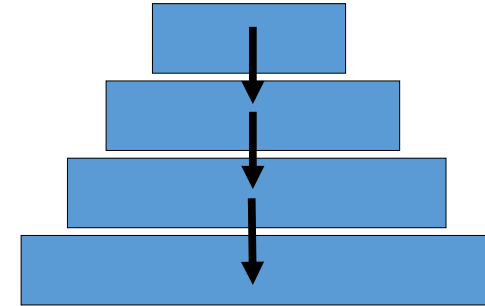
- Standard length (SL) is used throughout. Terminology and methods for taking counts and measurements follow Pietsch and Grobecker (1987). The holotype is deposited in the collections of the National Museum of Natural and Cultural History, Jakarta, Indonesia (NCIP). Symbolic codes for additional institutions are those provided by Leviton et al. (1985).
- Whole genomic DNA was extracted from skeletal muscle of the holotype of the new species and three specimens of *Histiophryne cryptacanthus* (tissues unavailable for *H. bougainvilli*) using the QIAamp DNA Mini Kit (Qiagen). Three outgroup taxa were chosen. . . .

## The Results

1. Verbal description of the findings of the study as they pertain to the hypotheses and goals, in the order in which the hypotheses were posed.
2. Figures (as needed).
3. Tables (as needed).
4. Statistical analysis (as needed).
5. No interpretation, no comparison, just the facts, with no editorializing.

## The Discussion

- Begin with the interpretation of the data, with respect to the specific objectives of the study, and then get progressively broader, interpreting papers by others, ending with the concepts used to start the Introduction.



## Acknowledgments

1. Common professional courtesy (distinct from authorship, although this can be contentious).
2. Indicate source(s) of financial support.
3. People who contributed with help in the field and/or lab, with ideas, statistic analysis, etc., (those whose contributions were less than those expected for co-authorship).
4. Only professional, not emotional help (find other ways to thank your mother or your boyfriend).

## Literature Cited (References)

1. Acknowledges the work done by others.
  2. Allows the reader to learn more.
  3. Bolsters arguments and facilitates interpretation of results.
- Everything cited in the paper must be listed, and nothing else. This is not a bibliography but strictly a list of relevant papers on the subject, only the ones actually used in the paper. They must be listed in alphabetical order, in the format specified by the selected journal.

## Reading A Paper

- Most of us never read a paper from start to finish:
  1. Read the **title** first,
  2. then the **abstract**,
  3. then the **last paragraph of the Introduction**,
  4. then the **first paragraph of the Discussion**,
  5. look at the **figures and tables**.
- So, each part of a paper must be written to attract reader's interest.

## Writing A Scientific Paper

### Structure of an Introduction: The inverted pyramid

**Broadest scope, designed to appeal to diverse readers**

Progressively narrower scope: concepts, species,

geographical scale, etc., with a smooth connection at each transition to avoid

losing any readers that we started with.

**Study goals:  
hypotheses**

## INTRODUCTION SECTION

## Developing an Introduction

The first and last paragraphs of the Introduction “pin down” the paper by defining the broadest scope of the paper and the specific goals.

- The broadest scope, in the first paragraph, depends on the audience. If you are writing for a fish or fisheries journal you may start with fish concepts or themes, whereas a paper in an ecology or behavior or evolution journal might begin with general themes and examples from other taxa before narrowing the focus to fishes.
- The last paragraph needs to be very specific, expressing the overall objectives and specific hypotheses of the study. The more specific the better.

## The Introduction: Structure within paragraphs

- Each paragraph should have topic sentence, a series of sentences in logical order, and a concluding sentence that provides a link to the next paragraph.
- Awkward transitions between paragraphs are a sure way to lose readers (or points on papers, if you care about that).

## The Introduction: Goals, Objectives, and Hypotheses

1. The beginning is essential if you are to draw in readers from a wide range of disciplines, which you should want to do. Where to begin? This depends on the intended audience and what you perceive to be the most interesting aspect.
2. The paragraphs that follow must flow smoothly, leading progressively to sharper focus on the specific goals and hypotheses. Do not over-emphasize details such as site and species too early or you will drive away prospective readers.
3. The last paragraph is crucial; it lays out the overall goals or objectives and the specific hypotheses or predictions. All these concepts must have been foreshadowed by text earlier in the Introduction. **Do not spring something on the readers that they do not expect!**

## MATERIALS AND METHODS SECTION

## Materials and Methods: Describing How You Did What You Did

- Need to provide sufficient detail to allow a reader to envision what was done and to repeat the procedures if needed.
- The difference between trivial and critical details may depend on the goals of the study.
- Sub-sections (indicated by subtitles) may be useful for organization (e.g., field sampling and lab procedures, etc.).
- Do not list steps of procedure.
- Do not describe routine lab practice, common equipment or containers.

## Materials and Methods: Some Rules

1. Always use the past tense.

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3. Subheadings should differ in font and position from major headings.
4. The reader should be able to see, in his or her mind's eye, the activity, and should be able to recreate what was done. This allows readers to decide whether or not what we did was legitimate, and allows them to replicate the study or experiment as much as possible. If a reader could not understand what you did and could not replicate it, there is insufficient detail.

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5. How much detail is too much? It depends on the nature of the study. What is trivial for one study may be essential for another. But, do not repeat routine lab procedures or describe common lab equipment or containers.

## Materials and Methods: Use of Diagrams/Figures

- Diagrams and other figures can help describe the methods.
- A diagram of an apparatus that is not common in the lab can be very informative and save space compared to text.
- A diagram can often be improved by the addition of a line drawing, e.g., of the organism or something similar.

## RESULTS SECTION



## Results: How to describe what you found

- Describe what you found in a logical sequence (as hypothesis posed).
- Use headings and subheadings.
  1. For clarity and ease of understanding, it is important to break up the narrative of your paper into subheadings of two, three, or four levels (orders) of importance, each level indicated by a distinctive typography and position relative to the text.
  2. If well constructed, the hierarchy of headings and subheadings serves as an easily understood outline of your paper.

## Headings and subheadings: Rules to follow

1. **The heading** (your title) and first-order subheadings are usually centered on the page, often set in larger-font and bold-face but not italics, with space left above and below, and never followed by a period. For example:

### **Fishes of the Salish Sea**

#### **Introduction**

## Headings and subheadings: Rules to follow

2. **Second-order** subheadings are set flush left on the page, often set in bold-face but not italics, with space left above and below, and never followed by a period. For example:

### **Fishes of the Salish Sea**

#### **Introduction**

#### **Historical perspective**

## Headings and subheadings: Rules to follow

3. **Third-order** subheadings are set flush left at the beginning of a paragraph of text (sometimes called a run-in side-head), in bold-face, or italics if desired, and separated from the text by a period, but more often a dot-dash (.—). For example:

### **Fishes of the Salish Sea**

#### **Introduction**

#### **Historical perspective**

**Early exploration.**—Native Americans of the Pacific Northwest probably had an extensive knowledge of the ichthyofauna of what is now designated the Salish Sea. . . .

## Headings and subheadings: Rules to follow

- 4. **Fourth-order** subheadings are set indented at the beginning of a paragraph of text, sometimes in boldface (but usually not), and separated from the text by a colon. For example:

### **Fishes of the Salish Sea**

#### **Introduction**

##### **Historical perspective**

**Early exploration.**—Native Americans of the Pacific Northwest probably had an extensive knowledge of the ichthyofauna of what is now designated the Salish Sea. . . .

George Vancouver: Puget Sound was explored in detail by George Vancouver (1757–1798) and his crew in June and July 1792. . . .

## Headings and subheadings: things to avoid

- A common fault is to follow a subheading directly by a pronoun that refers to a word or phrase in the subheading; for example:

“Molecular approaches to phylogeny.—They are frequently used to understand. . . .”

## Headings and subheadings: Things to avoid

- A less serious fault is to repeat the subheading itself in the sentence that follows:

“Molecular approaches to phylogeny.—Molecular approaches to phylogeny are described as follows. . . .”

- Always avoid underlining to offset subheading (or for that matter items in the text); underlining is an editorial device meant to indicate italics and should be reserved for that purpose.

## Results: Three complementary parts

1. **Text:** Statement(s) in words about what you found.
2. **Figures:** Bar charts, scatter-plots, and other diagrams help visualize complex relationships and draw the reader’s attention to the most important findings.
3. **Tables:** Provide details on the results that are important (as opposed to impressions conveyed by figures) or that would be too complex or inappropriate for a figure (such as statistical test values, etc.). Some journals allow or even encourage “supplemental” or “appendix” tables for details, or even electronic storage of data for public access. Some journals actually require public access to your data.

## Results: Text

- You should be able to read the text without looking at the tables and figures and still understand the paper. Do not rely on figures.
- Avoid the following: “The pattern of fish density and depth is shown in Figure 1.” What is the pattern? You should not force the reader to study the figure.
- Better: “Dover sole density increased from the shallowest to the deepest depths sampled (Fig. 1).”
- Do not present results if they are not relevant to your goals and objectives. Just because you have the data does not mean you should report it.
- Always use the past tense!

## Results: Figures

- Figures should facilitate comprehension of the results, whereas tables preserve critical specific results.
- The default output of Excel is usually horrible as a figure. We must fix and modify them.
- Tables of raw data are never appropriate. Output from Excel Tables must always be re-formatted.

## Results: For Better Understanding:

- Examine Results section text from published papers. Look at how the text is organized, how the authors refer to tables and figures, how subheadings are used (or not).

How to use figures effectively in the Results section

## The importance of figures

### “A picture is worth a thousand words”

Vision is probably the most important sensory system for humans, and we are instinctively drawn to images: art, photographs, and other visual stimuli. As authors, we should exploit this instinct to draw the reader's attention to the most important findings or concepts. We do this by

1. Depicting the key results as figures,
2. Polishing them to optimize the information content,
3. Presenting only the most important findings in figures. A barrage of graphs is not effective. The reader gets overwhelmed and misses the most important ones.

## Concepts for data visualization

### •Your figures should:

1. Present your most interesting data.
2. Communicate complex ideas clearly and efficiently.

### • When creating figures, you should:

1. Try to eliminate clutter and unrelated information.
2. Include information such as inserts and labels to guide the reader through the figure.

## The importance of the caption

- Each figure (as well as table) must have a fully self-explanatory caption (sometimes called a legend). This means that a reader should be able to look at the figure and the caption and understand what is being presented.
- By convention, figure captions are nearly always placed below the image (whereas captions describing tables are nearly always placed above).
- Remember, the reader is busy and may skim the paper, notice a figure that seems interesting, and stop to look at it. Do not force the reader to study the whole paper to puzzle out what is being shown.

## Graphs are the most common way to display data

- But almost any other kind of image is possible. Whatever best provides a visual display of the primary message that you are trying to send: maps, charts, photographs, electron micrographs, line drawings, half-tone illustrations, whole organisms, parts of organisms, etc., etc.

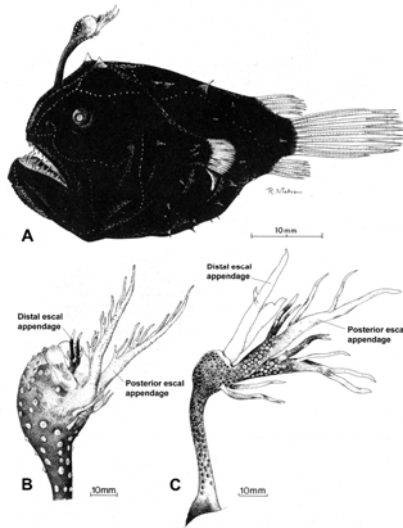


Fig. 4. Species of the *Himantolophus appellii* group: (A) *Himantolophus* sp., 38 mm SL, AMS I.20314-013 (after Bertelsen and Pietsch, 1983); (B) esca of *Himantolophus* sp., 39 mm SL, AMS I.16162-018 (after Bertelsen and Pietsch, 1983); (C) illicium and esca of *Himantolophus appellii*, 225 mm, IOAN 40510 (after Bertelsen and Krefft, 1988).

## What makes a successful graph?

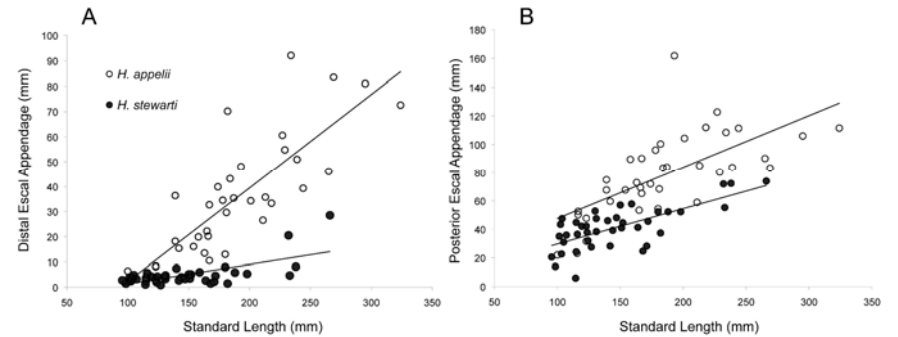


Fig. 5. Relationship between escal appendage length and standard length in two species of the *Himantolophus appellii* group, based on known female specimens greater than 95 mm SL: (A) Distal escal appendage; difference between means significant at  $p < 0.0001$  (ANCOVA:  $F = 47.31$ ); (B) Posterior escal appendage; difference between means significant at  $p < 0.0001$  (ANCOVA:  $F = 36.39$ ).

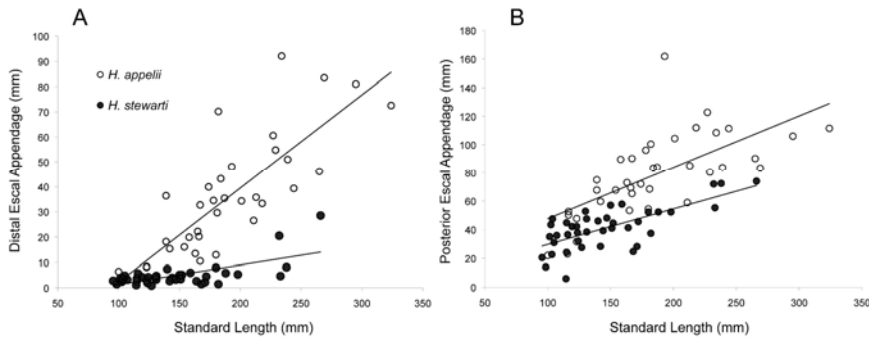
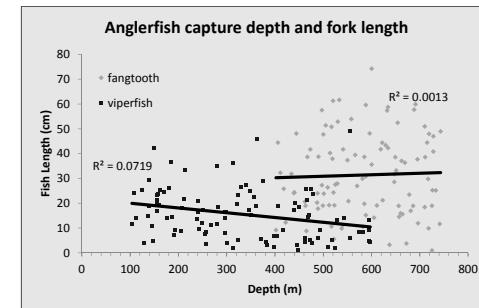


Fig. 5. Relationship between escal appendage length and standard length in two species of the *Himantolophus appellii* group, based on known female specimens greater than 95 mm SL: (A) Distal escal appendage; difference between means significant at  $p < 0.0001$  (ANCOVA:  $F = 47.31$ ); (B) Posterior escal appendage; difference between means significant at  $p < 0.0001$  (ANCOVA:  $F = 36.39$ ).

### Key points:

- Describes dependent (Y-axis) and independent (X-axis) variables
- Clearly specifies limits of the data
- Symbols are clearly differentiated
- Provides statistical support

## Types of graphs: scatterplots



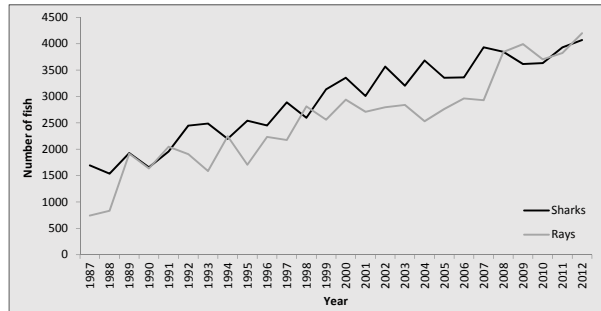
### Attributes:

- Shows relationship between data
- Independent data (x axis) influences dependent data (y axis)
- Good for continuous data
- Can show trends
- Shows exact values—no summary statistics (unless specified)

### Warnings:

- Make sure data are continuous
- Do not infer relationship from trend only
- Make sure multiple series on graph are comparable (same scale)

## Types of graphs: line graphs



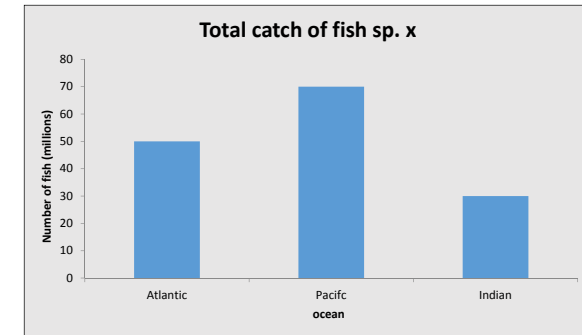
### Attributes:

- Shows changes over time
- Can show trends in multiple series of data
- Indicates values between data points
- Patterns are readily apparent

### Warnings:

- Data must be continuous
- Lines indicate values between points, so intermediate values must be valid
- Make sure multiple series on graph are comparable (same scale)

## Types of graphs: bar graphs



### Attributes:

- Good for displaying non-continuous data
- Each bar represents a discrete data point
- Multiple bars can compare data series
- Patterns are visually striking
- The order of the bars can reveal patterns

### Warnings:

- Should never be used for continuous data
- Bars can be unintentionally ordered to depict false trends

## Examine figures

- What are the strengths and weaknesses? Could we see ourselves making these same mistakes?

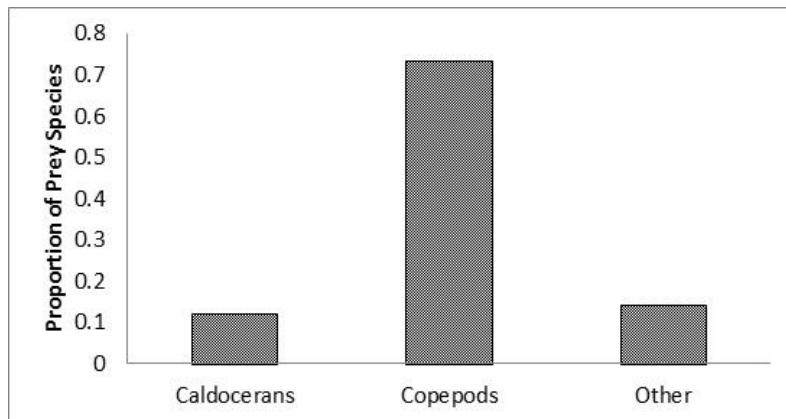


Fig. 1. Graph showing average prey proportions in Lake Washington. Calculated from data collected from 1993-2011

## Examine figures

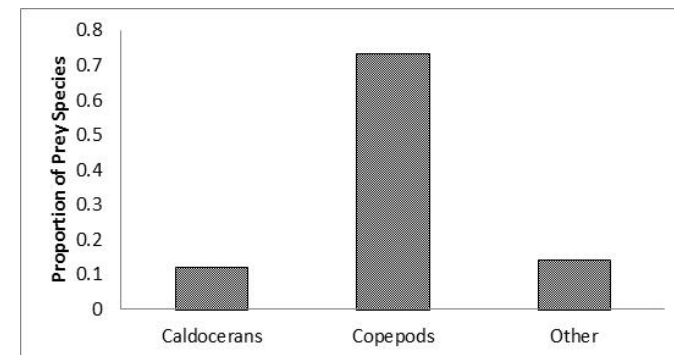


Fig. 1. Graph showing Average prey proportions in Lake Washington, calculated from data collected from 1993-2011.

- Critique: This figure is boring to look at and contains only three data points: the proportions of the three prey species. The information could easily be included in the text, expressed in a single sentence. The caption is inadequate.

## Examine figures

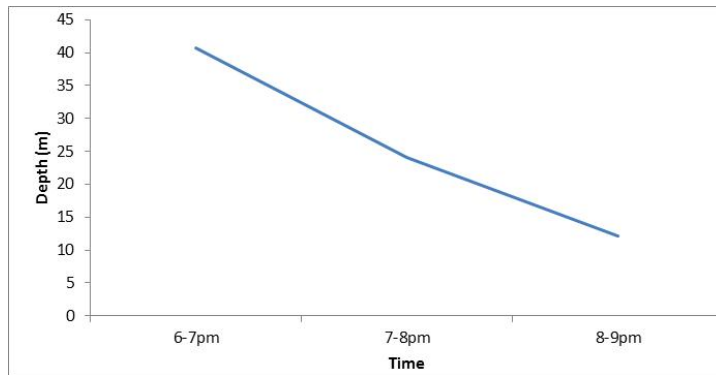


Fig. 1. Showing the vertical migration pattern of the 3-Spine Stickleback from 2000 – 2010 during fall

## Examine figures

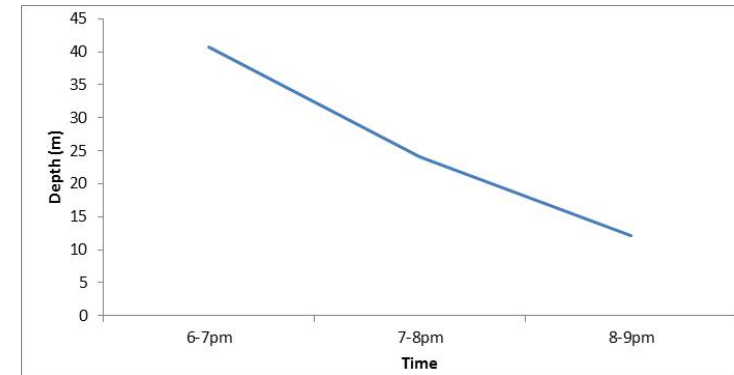


Fig. 1. showing the Vertical migration pattern of the 3-Spine Threespine Stickleback from 2000–2010 during fall.

**Critique: There are only three data points, and the line is inappropriate. The caption is inadequate.**

## Examine figures

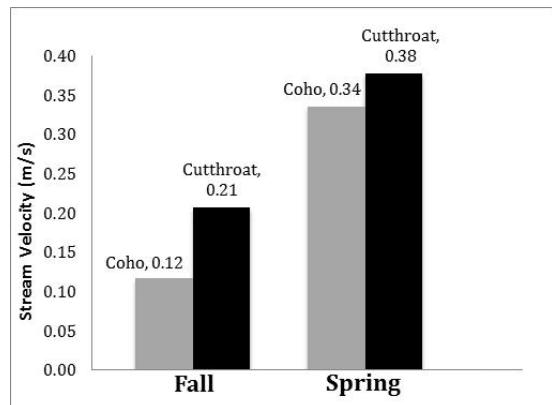


Fig. 1. Average stream velocity of habitat where fish were captured in Rock Creek

## Examine figures

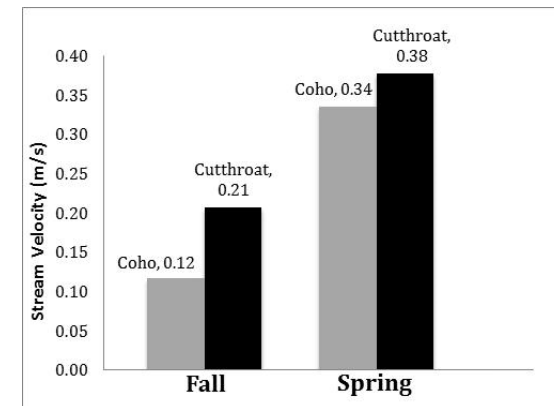


Fig. 1. Average stream velocity of habitat where fish were captured in Rock Creek

**Critique: The figure has the data in numerical form as well as the height of the bars, and this is redundant. This is also not the most appropriate format for displaying means.**

## Examine figures

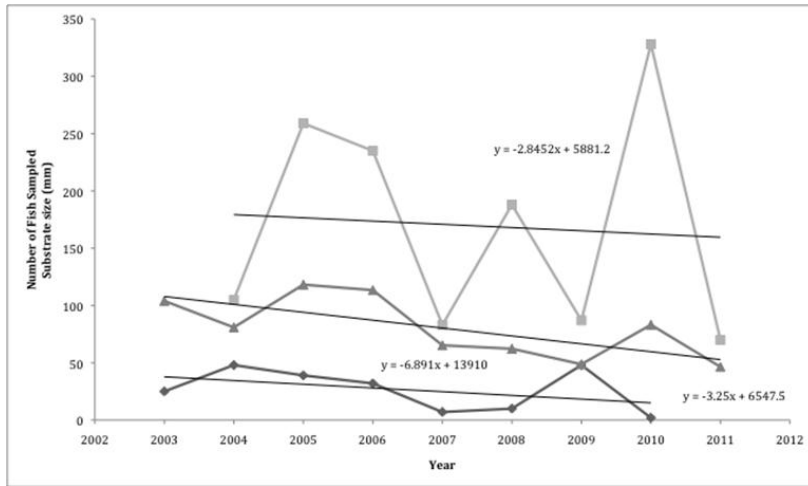


Figure 3. Plot of the number of Torrent Sculpin (light grey, top) and Cutthroat Trout (black, bottom) sampled each year, compared to a plot of average substrate size in mm for each year of habitat sampling (grey, middle). All three plots have negative trendlines

## Examine figures

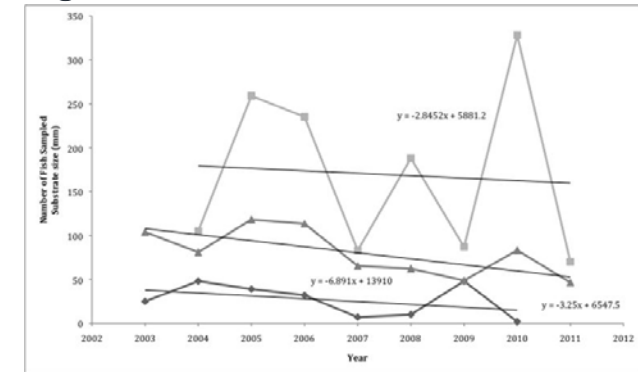


Figure 3. Plot of the number of Torrent Sculpin (light grey, top) and Cutthroat Trout (black, bottom) sampled each year, compared to a plot of average substrate size in mm for each year of habitat sampling (grey, middle). All three plots have negative trendlines

**Critique: Lines connecting data points are inappropriate. Y-axis should not represent both number of fish and substrate size. The formulas clutter up the figure; put them in the text or caption. Avoid interpretation in caption; just tell us what we are seeing.**

## Examine figures

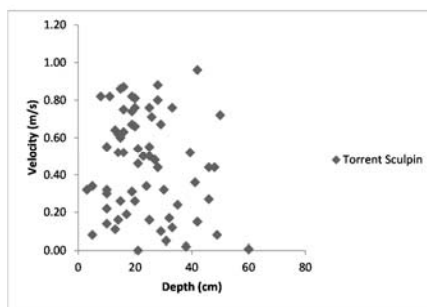


Fig. 1. Water depth and velocity where fish were caught.

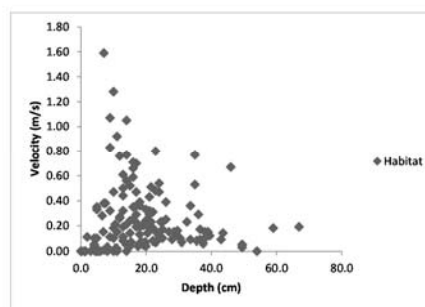


Fig. 2. Water depth and velocity at random points in the creek.

## Examine figures

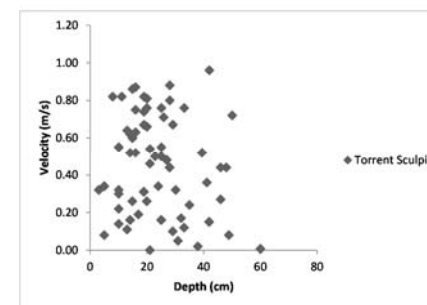


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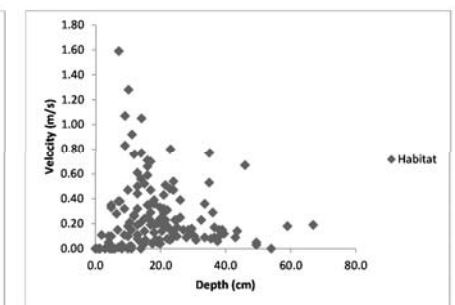


Fig. 2. Water depth and velocity at random points in the creek.

**Critique: The information in these figures is more or less parallel. Can the two data sets be merged into a single figure to make more efficient use of space?**



## Examine figures

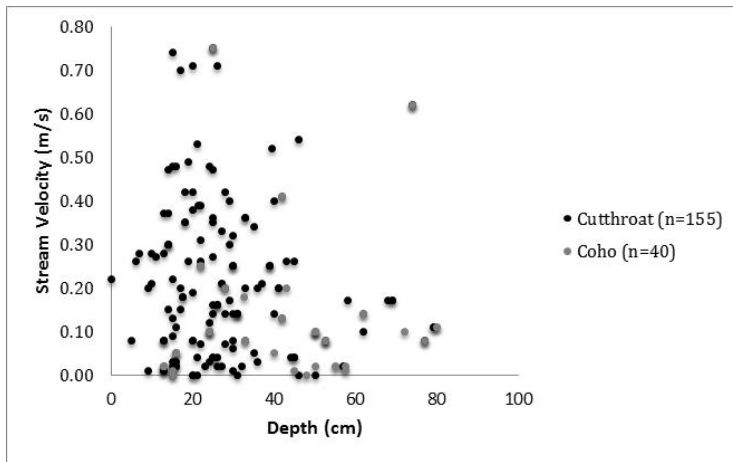


Fig. 1. Stream velocity vs. habitat depth occupied by captured fish in Rock Creek (fall)

**Critique: This is much better, but the two sets of points need more distinct symbols.**

## Examine figures

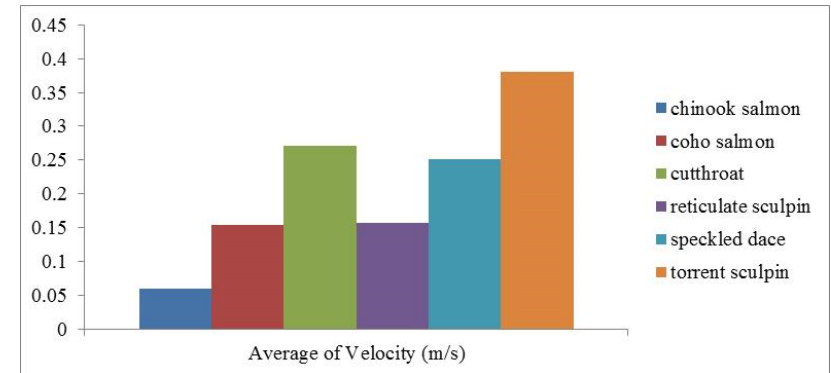


Fig. 1. The average velocity (m/s) of where the in-stream species were found.

## Examine figures

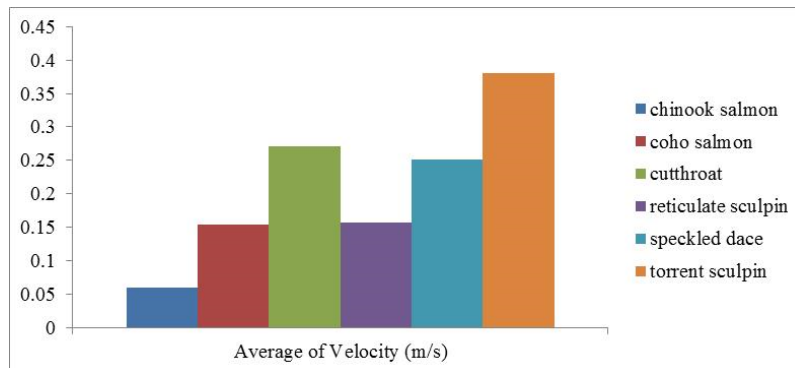


Fig. 1. The Average velocity (m/s) of where the instream species were found.

**Critique: The y-axis has no label but, worse, the label on the x-axis belongs on the y-axis. More fundamentally, why are the species listed in this order? It is alphabetical but so what? What is the message here? Can the labeling scheme be better constructed?**

## Examine figures

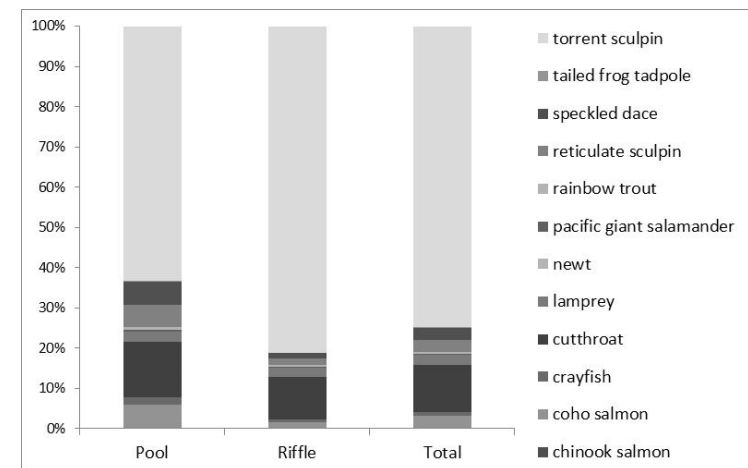


Fig. 1. The proportions of all species found at the two different habitat types throughout Rock Creek.

## Examine figures

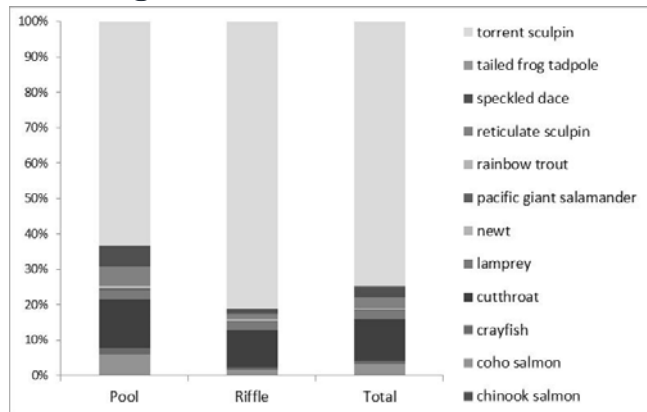


Fig. 1. The proportions of all species found at the two different habitat types throughout Rock Creek.

**Critique:** Many of the species are represented by such a sliver on the bar that we cannot estimate their proportion by eye. In addition, the shades of gray are difficult (impossible?) to distinguish.

## Examine figures

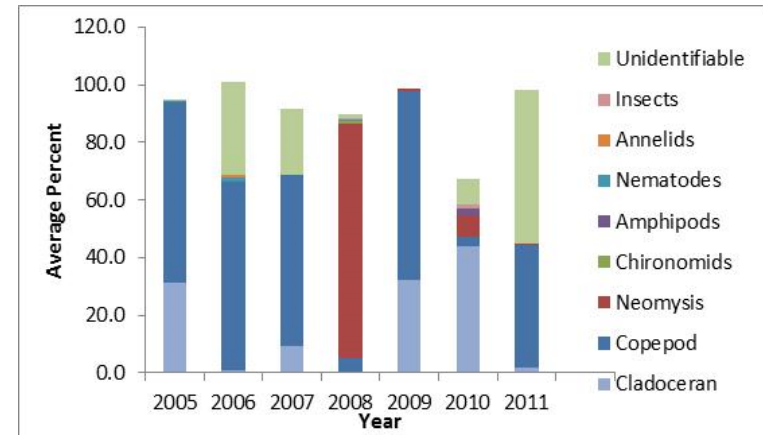


Fig. 1. The average percent of different organisms found in the stomach contents of *Gasterosteus aculeatus* per year. While copepods and cladocerans appear to be an important part of the diet, there are large fluctuations in consumption pattern depending on the year.

## Examine figures

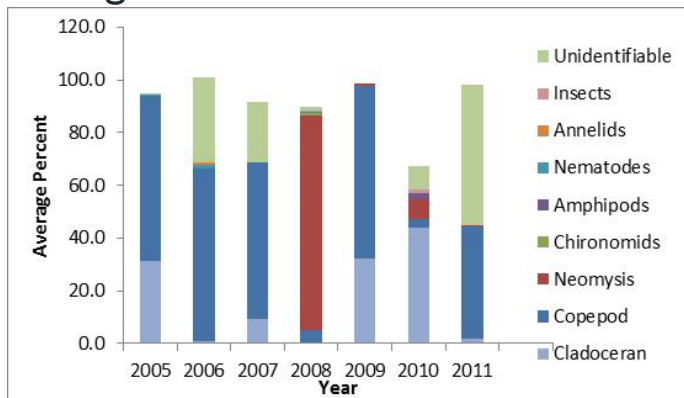


Fig. 1. The average percent of different organisms found in the stomach contents of *Gasterosteus aculeatus* per year. While copepods and cladocerans appear to be an important part of the diet, there are large fluctuations in consumption pattern depending on the year.

**Critique:** Why don't the bars add up to 100%? And why does the scale go to 120%?

## Examine figures

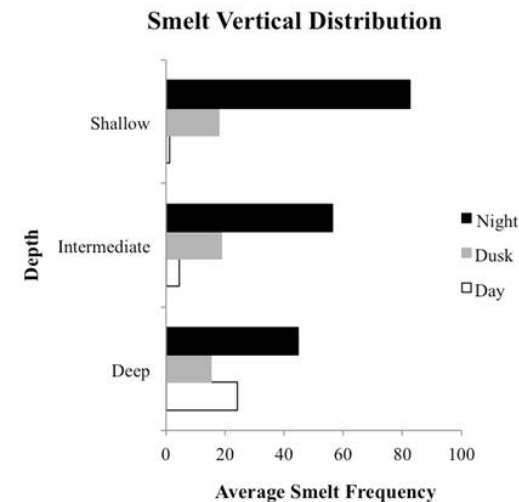


Figure 1. Average smelt frequencies across adjusted diel periods and depth categories.

## Examine figures

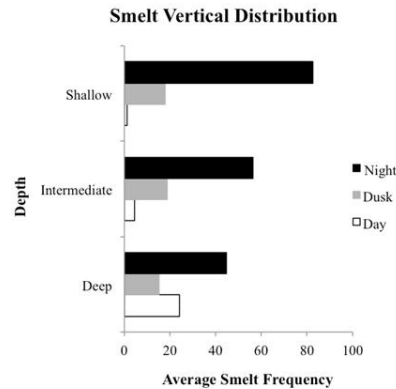


Figure 1. Average smelt frequencies across adjusted diel periods and depth categories.

**Critique: Not too bad, makes spatial sense and well coded by time of day, but no actual depths are given and why just “smelt”? Do you know how many species of smelt are recognized?**

## Summary tips for figures:

1. Use black and white for papers, reserve color for oral presentations.
2. Use the space efficiently—avoid a lot of “negative space.”
3. If there is too little “information content” (e.g., only two or three data points), consider putting the data in the text.
4. If there is too much “information content” the reader will miss the important point or cannot discern some of the data; consider trimming the data in some way or presenting the data in table form.
5. Make sensible use of decimal places.
6. Label X and Y axes and know the difference between the independent variable (on the X-axis) and the dependent variable (on the Y-axis).
7. Try vertical and horizontal presentations to see which is more intuitive.
8. Avoid drawing lines between points unless you really need to do so, as this implies continuity of values.
9. Avoid gridlines unless you really need them to make a point.
10. Avoid gray backgrounds.

## How to use tables effectively in the Results section

### What makes a successful table

- Just as with figures, your tables should present only your most interesting and/or most crucial data.
- Tables should be used to display supporting data that cannot be effectively communicated in any other way.
- When constructing tables, you should always eliminate clutter and unrelated information.
- Remember, the reader is busy and may skim the paper, notice a table that seems interesting, and stop to look at it. Do not force the reader to study the whole paper to puzzle out what is being tabulated.

## The importance of the caption

- Each table must have a fully self-explanatory caption (or legend). This means that a reader should be able to look at the table and the caption and understand what is being presented.
- By convention, table captions are nearly always placed above the table (whereas figure captions are usually placed below the image).

## Examine Tables:

Plankton Type	P-Value
Copepod	0.004939
Neomysis	0.302102
Cladoceran	0.872516

Table 1. The P-values associated with selectivity versus availability of three groups of organisms, copepods, neomysis, and cladocerans, by the 3-spine stickleback *Gasterosteus aculeatus*.

## Examine Tables:

Plankton Type	P-Value
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Table 1. ~~The~~ P-values associated with selectivity versus availability of three groups of organisms, copepods, neomysis, and cladocerans, by the Threespine 3-spine Stickleback *Gasterosteus aculeatus*.

**Critique: This is really a list rather than a table. Tabulations with statistical values like this waste space. Put the values in the text and do not use so many significant digits! Moreover, the caption is awkward (incomprehensible?) and incorrectly located (table captions are placed above the table).**

## Examine Tables:

	Velocity (m/s)	depth (cm)	substrate (mm)
average	0.315484729	22.00874087	115.6554054
standard deviation	0.29605675	16.43507372	84.17514793
CV	93.84186397	74.67521118	72.78098901

Table 1. The average, standard deviation, and the coefficient variable of the velocity (m/s), depth (cm) and the substrate size (mm) of the intermediate axis.

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Table 1. ~~The~~ average, standard deviation and ~~the~~ coefficient variable of the velocity (m/s), depth (cm) and the substrate size (mm) of the intermediate axis.

**Critique: This example is more than a list—it would be difficult to place in the text—but we can reduce the number of decimal places here too. Formatting can be improved in several ways to improve ease of reading, and the caption (which is poorly worded) needs to be moved to the top.**

## Examine Tables:

Table 1. Showing the average values of the depth and velocity of the distribution of the sculpin and the habitat.

		Average depth	Average velocity
2004	Torrent sculpin	23.9	0.50
	Habitat	26.4	0.38
2010	Torrent sculpin	25.0	0.45
	Habitat	17.5	0.23

## Examine Tables:

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	Habitat	17.5	0.23

**Critique: The caption is not a complete sentence much less a clear one. In addition, the boxes that enclose the data should be minimized or better, avoided altogether. The Latinized scientific name must be added—there are 70 genera and about 275 recognized species of sculpins, 37 in Puget Sound alone!**

## Examine Tables:

Table 1. Total number of Cutthroat Trout and Torrent Sculpin caught per year in each habitat type. For all years except 2004, more fish of each species were caught in the riffle area.

Year	Pool Cutthroat trout	Torrent sculpin	Riffle Cutthroat trout	Torrent sculpin
2004	16	36	9	69
2005	17	85	31	174
2006	19	86	20	149
2007	17	27	15	56
2008	2	44	5	144
2009	2	19	8	68
2010	18	97	30	231
2011		27	2	43
Grand Total	91	421	120	934

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2010	18	97	30	231
2011		27	2	43
Grand Total	91	421	120	934

**Critique: This is not bad, but the box should be removed and scientific names added. Also, resist the temptation to interpret the data or tell the reader what to make of it. So, the second sentence of the caption should be dropped.**

## DISCUSSION SECTION

## Tips for tables:

1. Use the space well: avoid a lot of “negative space.”
2. Consider carefully what the columns and rows should be—one can present a very different emphasis depending on how the table is laid out.
3. If there is too little “information content” (e.g., two or three numbers) then consider putting the data in the text.
4. If there is too much “information” that the reader will miss the important point—consider trimming the data in some way.
5. Make sensible use of decimal places.
6. Try vertical and horizontal presentations to see which is more intuitive.

## Basic hints and things to avoid:

1. The Discussion should begin with a direct link between the Results and the hypotheses and/or goals or questions stated in the Introduction. It can be helpful to briefly restate the hypotheses.
2. Don’t mix things up—keep the questions/hypotheses in the same order as presented in the Introduction.
3. Discuss your data in the context of the hypotheses. Was each hypothesis supported or not?
4. Then back away slowly, interpreting the results in the light of similar work by others, citing references were appropriate.
5. End where you began, with the broad scope of the Introduction.

## IMPROVING WRITING

### Suggestions for better writing:

1. Cutting jargon, trimming sentences, and avoiding redundancies.
2. Using correct punctuation and grammar.
3. Why grammar matters: the comma.
4. Peer editing of written papers.

### Avoid jargon and seek simplicity, brevity, and clarity

<u>Jargon</u>	<u>Simple, brief, and clear version</u>
A considerable amount of	much
A considerable number of	many
A decreased amount of	less
A decreased number of	fewer
A majority of	most
A number of	many
A small number of	few
Absolutely essential	essential
Accounted for by the fact that	because
Adjacent to	near
Along the lines of	like
An adequate amount of	enough
An example of this is the fact that	for example

### Trimming sentences by reducing “fat phrases”

<u>Fat phrase</u>	<u>Reduction</u>
At this point in time	now
At that point in time	then
Has the ability to	can
Has the potential to	can
In light of the fact that	because
In the event that	if
In the vicinity of	near
Owing to the fact that	because
The question as to whether	whether
There is no doubt that	no doubt
It is known that	[avoid altogether]
The fact of the matter is	[avoid like the plague]

## Common redundancies to avoid:

(already) existing	introduced (a new)
(alternative) choices	mix (together)
At (the) present (time)	never (before)
(basic) fundamentals	none (at all)
(completely) eliminate	now (at this time)
(continue to) remain	period (of time)
(currently) being	(still) persists
(currently) underway	(separate) entities
(empty) space	start (out)
Had done (previously)	tuna (fish)

## Punctuation

**Why does it matter if I use “correct” punctuation?  
It just slows me down, and everybody  
knows what I mean.**

**But without punctuation, try making sense out of  
this crazy string of words:**

“Who do you think I saw the other day the Dalai Lama  
said my Aunt Minnie”

Patricia O’Conner, 1996, *Woe is I*, Riverhead Books, New York.

## Punctuation

**There are at least two very different possibilities:**

“Who do you think I saw the other day?” the Dalai Lama said:  
“my Aunt Minnie.”

“Who do you think I saw the other day? The Dalai Lama!”  
said my Aunt Minnie.

Patricia O’Conner, 1996, *Woe is I*, Riverhead Books, New York.

## Punctuation

**What does this sentence mean? Is the meaning clear?  
Can it be improved with proper punctuation?**

“A woman without her man is nothing.”

Lynne Truss, 2003, *Eats, Shoots & Leaves*, Gotham Books.



## Punctuation

**Again, there are at least two different possibilities, with opposite meanings:**

“A woman, without her man, is nothing.”

**or**

“A woman: without her, man is nothing.”

## Punctuation

**Are there any rules or is it all arbitrary?**

Isn't the language supposed to change over time? It does, whether we want it to or not. Why do the French fight so hard against change to their language?

*“Everyone has always regarded any usage but his own as either barbarous or pedantic.”*

Evelyn Waugh

## Grammar and Proper word use

- Proper use of grammar (punctuation, word order, etc.) clarifies the meaning of strings of words so that we can be sure we understand precisely what is written.
- In social discourse and in science, the normal goal is communication so we want people to understand us.
- Unlike oral communication, in writing we cannot use hand gestures, facial expressions, or tone of voice. So, the writing has to be precise.

## Grammar and Proper word use

The English language has a huge vocabulary and many words have similar but not identical meanings. Why not use the right word? Enjoy the richness of the language but be careful—too rich can lead to a flowery, pedantic (pompous) result.

## Grammar and Proper word use

- Sloppy writing conveys a disrespectful attitude toward the reader and also suggests other forms of sloppiness.
- If someone cannot take the time to check for mistakes in spelling, can you be confident that he or she collected the data carefully or ran the analyses correctly?
- Bad writing undermines the reader's confidence in the whole project.

## Why commas matter

What is the difference between:

“The people in line who managed to get tickets were satisfied.”

“The people in line, who managed to get tickets, were satisfied.”

## More on commas

“Leonora walked on her head a little higher than usual.”

“Leonora walked on, her head a little higher than usual.”

“The driver managed to escape from the vehicle before it sank and swam to the riverbank.”

“The driver managed to escape from the vehicle before it sank, and swam to the riverbank.”

“The convict said the judge is mad.”

“The convict, said the judge, is mad.”

## More on commas

“Using the comma properly announces that you have an ear for sense and rhythm, confidence in your style, and a proper respect for your reader.”

Or, less kindly:

“The rule is: don't use commas like a stupid person.”

Lynne Truss

## References

### Why do we refer to the work of others?

1. Acknowledges their contributions formally.
2. Allows the reader to learn more.
3. Bolsters arguments and facilitates interpretation of results.

Everything cited in the paper must be listed, and nothing else. This is not a list of relevant papers on the subject; that is, not a bibliography but a list of only those publications actually cited in the paper. They must be listed in alphabetical order, in the format specified by the selected journal.

### How to cite publications in the text:

1. "Our results were consistent with those reported by Jones and Smith (1997)." Note that we do not use first names nor initials.
2. "Our results were consistent with those reported by Jones et al. (1997)." By convention, two authors are named, but for three or more authors we just list the first, and then say "*et al.*," so it is Jones *et al.* (1997).
3. "The Long-horned Pricklefish is found in the Eastern Pacific Ocean, ranging from Prince William Sound, Alaska, to the mouth of the Columbia River (Harding, 2005)." Note that the period ending the sentence falls after the reference to the statement that comprises the sentence.

### Variations on the theme:

- Journals vary a lot in the specific ways in which they want papers cited in the text.
- Some use italics for "*et al.*" but most do not.
- Some use "&" instead of "and" as in "(Jones & Smith, 2004)."
- Some exclude the comma between author and date as in "(Jones and Smith 2004)."
- Everyone finds this journal-specific variation to be a huge pain (more on that soon) but we groan and bear it.

## How to list references:

1. List papers in alphabetical order by the last name of the first author, then by date, chronologically.
2. There is almost endless variation in style among journals but in general it is more or less like this:

**Jones, R. J., and S. T. Smith. 2005. Mass mortality of long-spine sea urchins: epidemiology and ecological consequences. *Marine Biology*, 74:345–356.**

## How to list references:

Variations include whether the second author's name goes before or after the initials, whether it is "&" or "and," whether the initials have periods or not (or if separated by commas), whether the year is in parentheses or not, whether the journal name is abbreviated or not, whether the volume number is in bold font, a space after the colon before the page numbers, italics here or there, etc., etc.

Jones, R. J., and S. T. Smith. 2005.  
Jones, R. J., and Smith, S. T. 2005.  
Jones, R. J., & Smith, S. T. 2005.  
Jones, R J, and Smith, ST. 2005.  
Jones R J and Smith ST (2005).  
*Marine Biology*, 74:345–356.  
*Marine Biology* 74:345–356.  
*Mar. Biol.*, 74:345–356.  
*Mar. Biol.*, 74: 345–356.

## How to cite "In" references:

Again, different journals have different styles but titles that are part of a larger publication, for example, a chapter within a book, are generally cited like this:

Bertelsen, E. 1984. Ceratioidei: development and relationships. pp. 325–334, In: Moser, H. G., W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., and S. L. Richardson (editors), *Ontogeny and Systematics of Fishes*, Spec. Publ. No. 1, American Society of Ichthyologists and Herpetologists, ix + 760 pp.

. . . Ceratioidei: development and relationships. pp. 325–334, In. . . .  
vs.

. . . Ceratioidei: development and relationships, pp. 325–334. In. . . .

## How to cite "In" references:

Bertelsen, E. 1984. Ceratioidei: development and relationships. pp. 325–334, In: Moser, H. G., W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., and S. L. Richardson (editors), *Ontogeny and Systematics of Fishes*, Spec. Publ. No. 1, Amer. Soc. Ichthy. Herpet., ix + 760 pp.

Note that titles of books and the names of journals are generally italicized (and words capitalized) while titles of papers within books and journals are not (and only the first word capitalized).

## Abstract

### Writing the Abstract

1. Consider the structure and function of the abstract.
2. Tips for writing the abstract.
3. A bit about “keywords.”
4. Examine abstracts in published papers.

The abstract is not a part of the paper at all!

The abstract is not just another section of your paper. It is often read in isolation, especially because many journals release the abstract free of charge, but not the body of the paper.

Therefore, it must contain all the elements of the whole paper, in proper order, but in miniature.

Some rules for abstracts:

1. Keep it short—typically no more than a page, double-spaced. Many journals set word limits (e.g., 300 words). One paragraph.
2. No citations—the reader cannot see the references.
3. Begin with the core question, goal, or hypothesis.
4. State the hypothesis concisely.
5. Describe the methods in brief.
6. Provide the key results, with some detail (e.g., mean values).
7. Give the reader the interpretation so he/she can get the whole story.

## Parts of the abstract

This list of five items provides a good outline of what should appear in an abstract:

- Aim (question, goal, or hypothesis):
- Study site(s): *for field studies only*
- Methods (materials):
- Results:
- Main conclusion:

## Title

## What makes a good title?

1. The title should indicate your most important result or discovery.
2. It should reflect your purpose in writing the paper.
3. Ask yourself, what is the main point you wish to make?
4. What new information does your study contribute?
5. A good title is specific and informative, but also provocative.
6. Exercise title is not enough for a title.

## Examples of titles, bad and better:

- These two titles provide little sense of direction or purpose:

**“A study of stream ecology”**

**“Nutrient uptake in seaweeds”**

- Compare them with more specific versions:

**“The effect of open and closed canopy on the diversity of macroinvertebrates in Rock Creek”**

**“Ammonia uptake by *Ulva curvata* growing on three different substrates”**

## More examples of titles, bad and better:

- These two provide little excitement or creativity:

**“Ecology and economics of crab in Puget Sound”**

**“Nitrogen availability and tree growth on the Queets River, Washington”**

- Compare them with more provocative versions:

**“Hypoxia in Hood Canal: Dungeness crab ecology, crabber response, and economic implications”**

**“Size matters: the relationship between soil nitrogen availability and riparian tree growth on the Queets River, Washington”**

## More examples of titles:

- Often the “question” title works well to spark interest:

**“Does bear predation inhibit mate choice in female salmon?”**

**“Cladistic analysis or cladistic classification?”**

**“Light, temperature, and desiccation tolerances of northwest bryophytes: can we conserve bryophyte diversity in an industrial forest landscape?”**

**“Patagonian toothfish: are conservation and trade measures working?”**

## Some examples of successful titles:

**“Crying wolf, crying foul, or crying shame: alien salmonids and a biodiversity crisis in the southern cool-temperate galaxioid fishes”**

**“The evolutionary history of seeing red: phylogenetic analysis of long-wave visual systems in the deep-sea dragonfishes”**

**“Dimorphism, parasitism, and sex: reproductive strategies among deep-sea ceratioid anglerfishes”**

**“Modulatory multiplicity in the functional repertoire of the feeding mechanism of cichlid fishes”**

Revision

## Integrating the sections: what goes where

It is important to edit words within sentences, sentences within paragraphs, and paragraphs within sections.

However, we also need to step back and look at what we put in the different sections.

## Check List

- 1. Does the Introduction start broadly and end with the objectives?**

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2. Does the Introduction give only enough of the approach to understand what is to come—some information but not too much detail?
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### **4. Does the Results section present all the available data needed to test all the hypotheses but no extraneous information?**

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5. **Does the Results section avoid interpretation, apologies, and other junk?**

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6. **Are the sample sizes, treatments and controls, replicates clear?**

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- 8. Are figures and tables cleaned up?**

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8. Are figures and tables cleaned up?
- 9. Does the Discussion connect the key results with the hypotheses?**

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- 10. Does the Discussion integrate the findings with work by others?**

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7. Do all figures and tables have complete, self-explanatory captions?
8. Are figures and tables cleaned up?
9. Does the Discussion connect the key results with the hypotheses?
10. Does the Discussion integrate the findings with work by others?
- 11. Does the Discussion end with an appropriately broad connection back to the themes of the Introduction?**

## More on Grammar

### It's vs. its

The **contraction** of "it is" = "it's."

For example, "It's mine, not his."

The **possessive** of "it" = "its."

For example, "Each book had its cover removed."

### The Law of Conservation of Apostrophes

*"For every apostrophe omitted from an it's, there is an extra one put into an its somewhere in the world."*

### It's vs. its

"To those who care about punctuation, a sentence such as "Thank God its Friday" (without the apostrophe) rouses feelings not only of despair but of violence. The confusion of the possessive "its" (no apostrophe) with the contraction "it's" (with apostrophe) is an unequivocal sign of illiteracy and sets off a simple Pavlovian "kill" response in the average stickler.

No matter that you have a Ph.D. and have read all of Henry James twice, if you persist in writing, "Good food, at it's best," you deserve to be struck by lightning, hacked up on the spot, and buried in an unmarked grave."

Lynne Truss, 2006, *Eats, Shoots & Leaves*, Gotham Books, New York.

### The semicolon

"The semicolon tells you that there is still some question about the preceding full sentence; something needs to be added. The period tells you that that is that; if you didn't get all the meaning you wanted or expected, anyway you got all the writer intended to parcel out and now you have to move along. But with the semicolon there you get the pleasant feeling of expectancy; there is more to come; read on; it will get clearer."

Lewis Thomas, 1979, *The Medusa and the Snail*, Viking Press, New York

## The hyphen and the dash

Hyphen: -  
En-dash: –  
Em-dash: —

The hyphen is used to connect or separate words.  
The en-dash is used to indicate a range as between page numbers.  
The em-dash dash is used to connect or separate phrases.

### Consider:

Little used car  
Superfluous hair remover  
Pickled herring merchant  
Two hundred odd members of the Republican party

## The proper use of a hyphen

- Use hyphens to avoid ambiguity. Consider:  
Re-formed vs. reformed  
Co-respondent vs. correspondent  
Re-mark vs. remark
- Also, for numbers:  
Forth-nine, twenty-three, etc.
- And certain prefixes:  
Anti-apartheid, quasi-normal, un-American, etc.
- And to avoid “letter-collision” in words like:  
Deice (de-ice) and shelllike (shell-like)
- But never in connection with adverbs, i.e., “ly” words:  
Barely-visible, widely-understood: WRONG  
Barely visible, widely understood: CORRECT

## The en-dash

- Use an en-dash to indicate a range of values:

Page numbers: Copeia, 2012:33–42  
Time: durations of 23–28 hours, 18–24 months  
Length: specimens measuring 33–78 mm standard length  
Depth: at bathypelagic depths of 1000–4000 m

- Don't insert a space on each side of an en-dash:

depths of 1000 – 4000 m: WRONG  
depths of 1000–4000 m: CORRECT

## The em-dash

- Use an em-dash (the equivalent of two hyphens) to set off a phrase for effect or in some cases as a substitute for parentheses ( ):

“Covering 16,925 square kilometers of sea surface and 7,470 kilometers of shoreline—including some 419 islands that provide a total land area of 3,660 square kilometers—the Salish Sea and surrounding lowlands provide habitat for at least 37 species of mammals, 172 birds, and 249 fishes.”

## The em-dash

- An em-dash can also be used in place of a colon to emphatically present some piece of information:

**“It was what Jack dreaded most—flat feet.”**

- Warning: never insert more than two em-dashes per sentence. If the gentler and less intrusive parentheses would work as well, use them instead.

**“Tina’s tackle box (along with all her lures) appeared to be lost.”**

- No need to insert a space on each side of an em-dash:  
**It’s something Fred simply could not do — stop smoking: WRONG**  
**It’s something Fred simply could not do—stop smoking : CORRECT**

## Brackets, round and square

- Use round brackets ( ) for parenthetical material (such as this) and for references (Jones and Smith, 2001) or the work of Jones and Smith (2001).
- Use square brackets [ ] when inserting a word in a quote that is understood from the context but not stated, and needed to properly understand the quote. “She had relied on them [snails] as her research subjects for years.”
- Also use square brackets around the Latin word sic “thus” when quoting text that “contains a mistake [sic] like this.”

## Ellipsis . . .

### Use the ellipsis

- When you omit material in the middle of a direct quote, “because otherwise . . . it would be too long, tedious, and/or extraneous.”
- Or to let a sentence trail off . . . in an intriguing manner, although this is rather informal and usually frowned upon in science, for some reason. . . .
- It’s always three dots to indicate a continuation but four when the end of a sentence is indicated.

## PLAGIARISM

## Plagiarism: A serious breach of ethics

Plagiarism is defined as “the unauthorized use or close imitation of the language and thoughts of another author and the representation of them as one’s own original work.” When students think of plagiarism, they often have in mind the most extreme cases, e.g., handing in a paper from a paper mill or inserting entire sentences written by someone else into a paper without providing any citation at all. It is important to note, however, that plagiarism can take any of a number of forms.

## Plagiarism: A serious breach of ethics

Plagiarism can take any of the following forms:

- Utilizing the words of another person without quotation marks or citation.
- Utilizing the ideas of another person without citation.
- Utilizing the words of another with citation but without quotation marks.
- Inappropriate paraphrase of another person’s language without citation.
- Copying another student’s paper or paper outline.
- Having a friend write your paper.
- Purchasing a paper from an on-line service.

## Why do people plagiarize?

1. Overly busy lives and poor time management skills.
2. Pressure to excel and succeed.
3. A lack of understanding about what constitutes plagiarism.
4. Difficulty understanding course material.
5. It’s so much easier, you don’t have to think!
6. Often it’s unintentional.

## Case of Plagiarism

- **The case of Doris Kearns Goodwin**, Pulitzer Prize-winning American biographer, historian, and an oft-seen political commentator.
- In 2002, *The Weekly Standard* determined that her book, *The Fitzgeralds and the Kennedys*, used without attribution numerous phrases and sentences from three other books.
- “I failed to provide quotation marks for phrases that I had taken verbatim, having assumed that these phrases, drawn from my notes, were my words, not hers.”
- She paid a large “private settlement” over the issue, but allegations of plagiarism caused her to resign her position as a guest pundit on the PBS NewsHour program.

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## Consequences of Plagiarism:

### **University of Memphis's policy is very clear:**

- **First offense: failing grade on assignment**
- **Second offense: failing grade for the course**
- **Third offense: suspension**

### **Must Read:**

#### **Academic Integrity at the University of Memphis**

A guide for students, faculty, and staff defining plagiarism and detailing how to avoid academic dishonesty.

<http://libguides.memphis.edu/c.php?q=94263&p=610843>

**Read the section "Avoiding Plagiarism"**