INSPIRING ECOLOGY

Teaching Tomorrow's Ecologists

WRITING WORKSHOP

Scientific Writing Made Easy

Dr. Martin Hughes

Practitioner Instructions

To the practitioners delivering this material. I would recommend the students take this material home with them, answer the questions and then discuss as a class in a tutorial setting where students can share their answers. During this session we can ask more probing questions about the structure of the scientific manuscript, whether they felt the graphs and tables helped or not, what they liked and what they would do differently.

After this tutorial I would give the students the answer sheet away with them and suggest they have it handy when it comes to writing their own scientific reports.

The art of scientific writing is often overlooked as we concentrate on the scientific process. The scientific process is rightly the focus of attention for undergraduates as this is fundamental to all scientific research. However, even if you have the best hypothesis, the best data and the best results - if you cannot communicate this effectively in a scientific manuscript your research is unlikely to make a big impact on the world and all of that hard work will be for nothing!

It is therefore imperative undergraduate students are taught the fundamental steps to writing a good scientific manuscript early in their academic careers.

Although a scientific manuscript may look overwhelming at first, they all follow the same basic steps and include key components. If students can follow these steps and incorporate these key components to their own manuscripts, they will be successful communicators in science.

In this tutorial we aim to dispel any myths you may have about writing a scientific manuscript and give you the tools and confidence to write your own.

After this tutorial you should be able to describe the structure of a scientific manuscript, identify the key components and extract important information from a published scientific manuscript. This will enable you to write a strong scientific manuscript.

This tutorial will be split into two parts:

In Part One you will read a manuscript titled ‘Scientific Writing Made Easy: A step-by-step Guide to Undergraduate Writing in the Biological Sciences’ and answer a list of set questions.

In Part Two you will read through a published scientific manuscript written by Dr Martin Hughes. The manuscript is missing important information which you must identify yourself. You will also examine the content of the manuscript and extract relevant information again using a list of set questions.

Part One

Scientific Writing Made Easy: A Step-by-Step Guide to Undergraduate Writing in the Biological Sciences

You have all been given a copy of 'Scientific Writing Made Easy: A Step-by-Step Guide to Undergraduate Writing in the Biological Sciences' by Turbeck et al., 2016 to read. As you go through the manuscript answer the following questions. You may wish to highlight or underline important elements of the paper. We would recommend reading the full paper first then re-read it with the question sheet in front of you.

Q1. What can effective writing achieve and how should it be presented?

Q2. What are the five key components of a scientific paper?

Q3. What do the authors of this paper hope these guidelines will help do?

Q4. Before you begin writing what three things should you consider?

Q5. What two search engines that you can use to find papers online do the authors cite?

Q6. What questions should you be asking yourself while you read other scientific manuscripts in preparation to writing your own?

Q7. What questions should you ask yourself when considering your audience?

Q8. What shape do the authors suggest you mimic while writing your introduction?

Q9. Explain why they suggest this shape.

Q10. The authors use the phrase '**specific question**' what is this also known as?

Q11. How much background information should you include in your introduction?

Q12. What format should we write an in-text citation?

Q13. What is the purpose of an in-text citation?

Q14. The authors provide a figure of an hour glass to illustrate how to structure a scientific paper. Sketch this figure and annotate appropriately.

Q15. The authors commit a lot of the paper discussing the ‘Knowledge Gap’. What is it, how do you mention it in a paper and why is it so important?

Q16. What three things should you define after the knowledge gap in the introduction?

Q17.What important aspects of your research topic can you state here?

Q18. When can you start writing your Materials and Methods section?

Q19. What is the aim of the Materials and Methods section?

Q20. How do you write your Materials and Methods section?

Q21. In what tense should the Materials and Methods section be written?

Q22. In Table 2 the authors list the common parameters of a Materials and Methods section. Copy these out.

Q23. What is the purpose of the Results section?

Q24. What should you identify before writing the Results section?

Q25. In what section should you interpret your results?

Q26. What two sections should your Discussion tie together?

Q27. How you should you begin your Discussion section?

Q28. Following the opening paragraph what should you do next in your Discussion?

Q29. What two questions should you be asking yourself during your Discussion.

Q30. What limitations do the authors discuss?

Q31. What is the last important part of the Discussion/ manuscript?

Q32. What should you do in this section?

Q33. What section of the hourglass does this section represent? What does this mean?

Q34. What should your take-home sentences focus on?

Q35. How should you end your take-home message?

Q36. What ‘little things’ will help connect your story.

Q37. What should you constantly be reminding yourself to bolster the flow?

Q38. How can passive voice be used effectively?

Q39. With regard to word choice what do the authors suggest you eliminate and do instead?

Q40. What can make the difference between getting a paper accepted or rejected or receiving a better grade in a report?

Q41. When editing your paper what should you do first? What questions should you ask yourself after doing this?

Q42. What else should you consider?

Q43. What should you do on the first run-through of your paper?

Q42. How do you check the flow of your paper?

Q43. What is the final thing you should do when editing?

Q 44. What should you do after editing your paper?

Q45. What are the benefits to peer review?

Answer Sheet for Part One

Q1. What can effective writing achieve and how should it be presented?

Answer: Effective writing can deepen understanding of the topic at hand by compelling the writer to present a **coherent** and **logical** story that is **supported** by **previous research** and **new results**.

Q2. What are the five key components of a scientific paper?

Answer:

1. Introduction
2. Hypothesis
3. Material and Methods
4. Results
5. Discussion

Q3. What do the authors of this paper hope these guidelines will help do?

Answer: We hope that the guidelines that follows, as well as the concrete examples provided, will lead to scientific papers that are **information rich**, **concise** and **clear**, while simultaneously alleviating frustration and **streamlining** the writing process.

Q4. Before you begin writing what three things should you consider?

Answer: How does your work fit into **existing literature**, crafting a **compelling story** and determining how to best tailor your message to an **intended audience**.

Q5. What two search engines that you can use to find papers online do the authors cite?

Answer: Web of Science and Google Scholar

Q6. What questions should you be asking yourself while you read other scientific manuscripts in preparation to writing your own?

Answer: What do we know about the topic? What open questions and knowledge do we not yet know? Why is this information important?

Q7. What questions should you ask yourself when considering your audience?

Answer: Who is my audience? What are their goals in reading my writing? What message do I want them to take away from my writing?

Q8. What shape do the authors suggest you mimic while writing your introduction?

Answer: A funnel

Q9. Explain why they suggest this shape.

Answer: The authors suggest your introduction should represent the beginning of a funnel. Start **wide** to put your research into a **broad context** that someone outside the field would understand, and then **narrow the scope** until you reach the **specific question** that you are trying to answer.

Q10. The authors use the phrase '**specific question**' what is this also known as?

Answer: A hypothesis.

Q11. How much background information should you include in your introduction?

Answer: Perform a thorough **sweep** of the literature; however, do not parrot everything you find. Background information should **only include** material that is **directly relevant** to your research and fits into your story; it **does not** need to contain an **entire history** of the field of interest.

Q12. What format should we write an in-text citation?

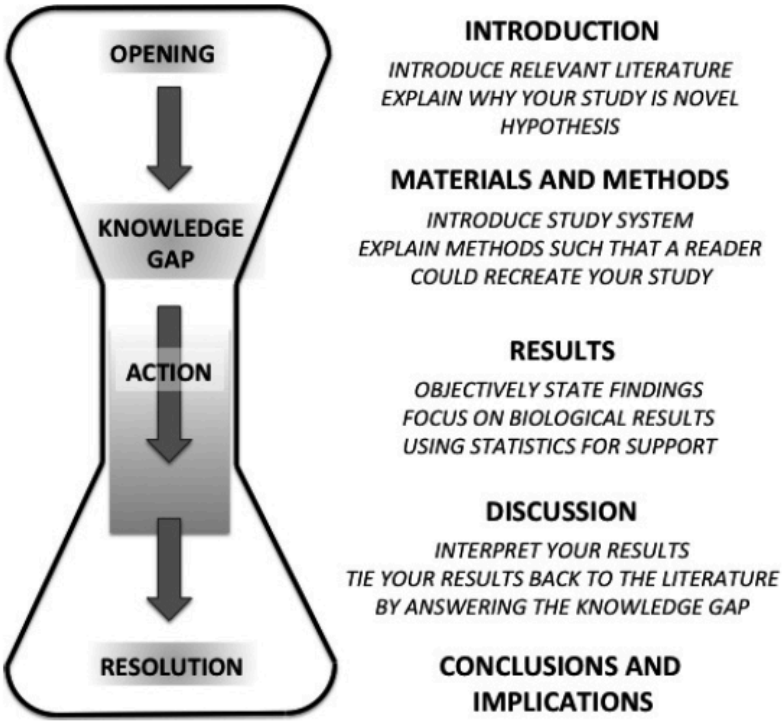
Answer: (Author, year published).

Q13. What is the purpose of an in-text citation?

Answer: First and foremost, it proves we **have examined** existing literature. By using in-text references we provide **support for arguments** or **statements** we may be making.

Q14. The authors provide a figure of an hour glass to illustrate how to structure a scientific paper. Sketch this figure and annotate appropriately.

Answer:



Q15. The authors commit a lot of the paper discussing the 'Knowledge Gap'. What is it, how do you mention it in a paper and why is it so important?

Answer: The knowledge gap is a **specific area** of the literature that contains an **unknown question** or problem, the knowledge gap tends to be a **small piece** of a much **larger field** of study. The knowledge gap is **explicitly stated** in your manuscript and will act as the **focal point** for your discussion and conclusions which will all be aimed at answering the knowledge gap. It is so important as it will **drive your hypotheses** and questions that you **design your experiment** to answer.

Q16. What three things should you define after the knowledge gap in the introduction?

Answer: the **hypothesis** you wish to address/ test, the approach of your **experiment** and a **brief overview** of your **experimental design** leaving specific details for methods section.

Q17.What important aspects of your research topic can you state here?

Answer: You can state your **system**, **study organism** or **study site**. You may wish to provide justification of why you chose the particular system for your research.

Q18. When can you start writing your Materials and Methods section?

Answer: While performing the experiment to avoid forgetting any details.

Q19. What is the aim of the Materials and Methods section?

Answer: To demonstrate that you used **scientifically valid methods** and provide the reader with enough information to **recreate your experiment**.

Q20. How do you write your Materials and Methods section?

Answer: In **chronological** order, clearly state the **procedural steps** you took, remembering to include **specific settings** of all equipment used and describe any **statistical analysis** performed.

Q21. In what tense should the Materials and Methods section be written?

Answer: Past tense

Q22. In Table 2 the authors list the common parameters of a Materials and Methods section. Copy these out.

Answer:

TABLE 2. Common parameters included in the Materials and Methods section.

- Site characterization:
  - Study organism used, its origin, any pre-experiment handling or care
  - Description of field site or site where experiment was performed
- Experimental design:
  - Step-by-step procedures in paragraph form
  - Sample preparation
  - Experimental controls
  - Equipment used, including model numbers and year
  - Important equipment settings (e.g., temperature of incubation, speed of centrifuge)
  - Amount of reagents used
  - Specific measurements taken (e.g., wing length, weight of organism)
- Statistical analyses conducted (e.g., ANOVA, linear regression)

Q23. What is the purpose of the Results section?

Answer: Provides a space to present your **key findings** in purely **objective** manner and lay the foundation for the Discussion section.

Q24. What should you identify before writing the Results section?

Answer: The **graphs**, **tables** and **data** that are absolutely necessary for telling your story.

Q25. In what section should you interpret your results?

Answer: The Discussion section. In the Results section **we only state** what we found, **we do not interpret** what we think these results mean until the discussion.

Q26. What two sections should your Discussion tie together?

Answer: The Introduction and the Results.

Q27. How you should you begin your Discussion section?

Answer: Begin by **explicitly stating the main findings** of your research. Remind the reader of the **knowledge gap** identified in the introduction and **re-spark curiosity** about the question you set out to answer. Then **explicitly state** how your experiment moved the **field forward** by filling in that knowledge gap.

Q28. Following the opening paragraph what should you do next in your Discussion?

Answer: Address your question and hypotheses with **specific evidence** from your results, if there are multiple **possible interpretations** of a result **clearly lay** out each competing explanations. Presenting and evaluating alternative explanations of your findings will provide **clear opportunities for future research**.

Q29. What two questions should you be asking yourself during your Discussion.

Answer: How do my results compare to those of similar studies? Are they **consistent or inconsistent** with what other researchers have found?

Q30. What limitations do the authors discuss?

Answer: Small sample size, procedural mistakes or known biases in the methods, this should be transparent and briefly discussed?

Q31. What is the last important part of the Discussion/ manuscript?

Answer: The conclusion.

Q32. What should you do in this section?

Answer: You should **summarise** the outcome of your study in a way that **incorporates new insights** or frames interesting questions that arose as a result of your research.

Q33. What section of the hourglass does this section represent? What does this mean?

Answer: The bottom of the hour glass so you should **broaden your perspective** again.

Q34. What should your take-home sentences focus on?

Answer: What you have **accomplished** and the **broader implications** of your study, rather than your study's limitations or shortcomings.

Q35. How should you end your take-home message?

Answer: On a **strong** note.

Q36. What ‘little things’ will help connect your story.

Answer: Flow, structure, voice and word choice.

Q37. What should you constantly be reminding yourself to bolster the flow?

Answer: Remind yourself of the **overarching** story; always connect new questions with resolutions and tie **new concepts** to previously presented ideas. As a general rule, try to maintain the same subject throughout a section and mix up sentence structure in order to emphasise different concepts. Keep in mind that words or ideas placed toward the end of a sentence often convey the most importance.

Q38. How can passive voice be used effectively?

Answer: It can **improve flow** by **strategically placing** a sentences subject so that it echoes the **emphasis** of the preceding sentence.

Q39. With regard to word choice what do the authors suggest you eliminate and do instead?

Answer: **Eliminate** any **flourish** and **choose** words that get your **point across** as **clearly as possible** will make your work much more enjoyable to read.

Q40. What can make the difference between getting a paper accepted or rejected or receiving a better grade in a report?

Answer: **Re-reading** your paper and incorporating **constructive feedback** from others.

Q41. When editing your paper what should you do first? What questions should you ask yourself after doing this?

Answer: Take some **time away** from your paper. Then ask yourself the following: Where **are the gaps** in your story structure? What has not been **explained clearly**? Where is the writing awkward, making it **difficult to understand** your point?

Q42. What else should you consider?

Answer: **Reading** the paper **out loud** first, and then print and edit a **hard copy** to inspect the paper from **different angles**.

Q43. What should you do on the first run-through of your paper?

Answer: Make sure you **addressed all the main ideas** of the story. One way to achieve this is by **writing down the key points** you want to hit prior to re-reading your paper. If your paper **deviates from these points**, you may need to delete some paragraphs. In contrast if you forgot to include something, add it in.

Q42. How do you check the flow of your paper?

Answer: Verify a **common thread** ties each paragraph to the preceding once, and similarly, that each sentence within a paragraph **builds on the previous** sentence.

Q43. What is the final thing you should do when editing?

Answer: You should **re-read** the paper and edit **sentence structure** and **word choice**. **Grammar** and **spelling** are just as important as your scientific story; a poorly written paper will have **limited impact** regardless of the quality and ideas expressed.

Q 44. What should you do after editing your paper?

Answer: Get **someone else to read it**. A classmate is ideal because he/she **understands** the assignment and could **exchange** papers with you. The editing steps described above when editing someone else's paper.

Q45. What are the benefits to peer review?

Answer: It may **help you identify sections** of your paper that need **clarification**. Don't be discouraged by negative comments – incorporating **feedback** of reviewers will only **strengthen** your paper. Good criticism is **constructive**.

Part Two

Now we will apply your knowledge of Part One by extracting relevant information from a real scientific publication. It is important to note here that we don't expect you to understand all the jargon of this paper, but you should be able to identify the key components and structure and flow. The publication written by Dr Martin Hughes is a short peer-reviewed scientific manuscript published in the Journal of Fish Biology. Unsurprisingly the main topic is about a type of fish…! However, what we want you to do is extract important information by reading through the publication and answering the following questions. Again please do not be overwhelmed by the scientific jargon, you should be able to answer these questions without understanding every single aspect of the paper. You may wish to refer to your answers from Part One to help with this section.

Q1. There are no sub-headings in the manuscript (i.e. Introduction, Material and Methods, Results and Discussion). Write the first sentence of the Introduction.

Q2. What is the broad topic introduced in paragraph one?

Q3. The first sentence of paragraph two sharpens the focus of the broad topic. What aspect of the broad topic is mentioned?

Q4. By the last sentence of paragraph two the focus is sharpened again, to what?

Q5. The ‘Knowledge Gap’ is mentioned in paragraph three. Write down what you think the knowledge gap of this paper is?

Q6. In Part One we discussed what follows the ‘Knowledge Gap’. The hypothesis you wish to address/ test, the approach of your experiment and a brief overview of your experimental design leaving specific details for methods section. Find this in the manuscript and write it here.

Q7. Write the first sentence of the Material and Methods

Q8. Can you name some of the statistical analysis conducted? Can you name the statistical software package used in this study?

Q9. Write the first sentence of the Results section.

Q10. Write the first sentence of the Discussion section.

Q11. What do you think the take-home message is?

Q12. What future studies do the authors propose?

Answer Sheet for Part Two

Q1. There are no sub-headings in the manuscript (i.e. Introduction, Material and Methods, Results and Discussion). Write the first sentence of the Introduction.

Answer: Apex predators are often associated with physically large habitat sizes, home ranges and generally low population densities.

Q2. What is the broad topic introduced in paragraph one?

Answer: Apex predators

Q3. The first sentence of paragraph two sharpens the focus of the broad topic. What aspect of the broad topic is mentioned?

Answer: Apex predators are vulnerable.

Q4. By the last sentence of paragraph two the focus is sharpened again, to what?

Answer: Aquatic apex predators

Q5. The 'Knowledge Gap' is mentioned in paragraph three. Write down what you think the knowledge gap of this paper is?

Answer: Identifying the mechanisms that promote expression of the life history type is a fundamental question in ecology; identifying lakes which support ferox *S. trutta* is essential to help direct conservation strategies.

Q6. In Part One we discussed what follows the 'Knowledge Gap'. The hypothesis you wish to address/ test, the approach of your experiment and a brief overview of your experimental design leaving specific details for methods section. Find this in the manuscript and write it here.

Answer: This study collates historical data on the distribution of lacustrine piscivorous *S. trutta* in Scotland from a wide range of sources. It combines distribution with data on lake characteristics to predict the underlying environmental characteristics that promote the emergence and maintenance of this life history form in Scotland.

Q7. Write the first sentence of the Material and Methods

Answer. To collate published records of ferox S. trutta, 20 angling books containing information on S. trutta locations in Scotland were digitised and scanned for records of: ferox *S. trutta* and large brown trout *S. trutta*.

Q8. Can you name some of the statistical analysis conducted? Can you name the statistical software package used in this study?

Answer. Analysis of Variance (ANOVA); Explained deviance (D^2); one-out cross validation and 10-fold cross-validation; Variance Inflation Factor; Probability Model.
R statistical software.

Q9. Write the first sentence of the Results section.

Answer: A high V_{IF} between maximum depth and mean depth was found (V_{IF} >10), maximum depth was subsequently removed from analysis and mean depth retained.

Q10. Write the first sentence of the Discussion section.

Answer: The presence of ferox *S. trutta* populations is also strongly associated with environmental factors (Table II).

Q11. What do you think the take-home message is?

Answer: Ferox *S. trutta* play an extremely important role in the continued maintenance of top down processes in post-glacial lakes where they occur. Their rarity implies a level of vulnerability to environmental change and exploitation.

Q12. What future studies do the authors propose?

Answer: Further studies on fine-scale ecological and biological mechanisms associated with ferox S. trutta will aid the design of appropriate management strategies for future implementation.