The Mechanics of Scientific Writing

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Day 1 Analysis and Structure
Day 2 IMRAD and Argue
Day 3 Tables, Figures, Citation, Punctuation
Day 4 Clarity and Cohesion
Day 5 Concision & Precision
Program

Day 1

**Analysis** – critical thinking from note taking to brainstorming

**Structure** – outlining: analytical, comparison & contrast, argumentative

Day 2

**IMRAD** – standard components of a publishable research manuscript

**Argue** – how to develop a thesis statement and persuade the reader

Day 3

**Tables and Figures** – how to make your writing understood

**Citation** – how to reference your sources.

**Punctuation** – how to make your writing accurate

Day 4

**Clarity** – six principles of clear writing

**Cohesion** – how to make your writing fluid

Day 5

**Concision & Precision** – how to make your writing tight and right

Review
For what good science tries to eliminate, good art seeks to provoke – *mystery*, which is lethal to one, and vital to another.

John Fowles
Articles

• Organization more than literary skill
• Sufficient information so reader can
  – Evaluate intellectual processes
  – Assess observations (of arguments or data)
  – Repeat experiments
• Logical structure is also suited for
  – Expository writing
  – Laboratory studies
Basic Structure

Physical sciences
- Introduction
- Methods
- Results
- Discussion & Conclusion

Social Sciences
- Introduction
- Theoretical analysis
- Applications
- Conclusions
Thesis, Dissertation, Article

Structure
Title
Abstract
Body (IMRAD)
References

Style
• UMB/department/journal
• Field specific
• International standards
  – Section numbers: ISO 2145
  – Citation/references: ISO 690
  – Quantities/units: ISO 31
• Early journals published “descriptive”
• Used in journal “letters,” case reports
• Methodology became important
• Growth of journals & standards
  – Structure to save space
  – Editing & review easier “indexing”
• **IMRAD** logic defined by questions
  – What question (problem) was studied? **Introduction**
  – How was the problem studied? **Methods**
  – What were the findings? **Results**
  – What do the findings mean? **Analysis & Discussion**
IMRAD structure

• Distinctive style with clear parts
  
  **Introduction**  *Why you did this work? What is its purpose?*
  
  **Methods**  *What materials did you use? How did you use them?*
  
  **Results**  *What did you discover?*
  
  **Analysis**  *What do your findings mean?*
  
  **Discussion**  *How does this relate to the problem?*

• IMRAD can be modified
  
  – If several methods are used, combine Methods with Results
  
  – If results are complex, combine Results with Discussion.
  
  – If discussion clearly conclude, combine Discussion with Conclusion
Sample (Thesis) Article

Natural/Physical Sciences

(CHapter I) Introduction
  Statement of the problem & purpose
  Significance of the study
  Research questions and/or hypotheses

(CHapter II) - Methodology
  Population and sampling
  Instrumentation (include copy in appendix)
  Procedure and time frame
  Analysis plan (type of statistical tests)
    Validity and reliability
    Assumptions
    Scope and limitations

(CHapter III) Results

(CHapter IV) Discussion & Conclusions
  Summary (of what you did and found)
  Discussion (why you think you found what you did)
  Recommendations (based on your findings)

REFERENCES
Introduction

• Put yourself in your reader's position - would you continue reading?
• Catch the reader’s attention
  Review pertinent literature
  Justification and objectives
• Present tense

Problem & Purpose

Significance of the Study

Research Question or Hypothesis
Introduction

Vital Statements

Problem

• Focus of research: one sentence with 1-3 paragraphs of elaboration
• Looking for
  – something wrong
  – something that needs close attention
  – new methods (old do not work)
  Fair trade policies are creating political instability and a loss of income in developing countries.
• Elaborate on problem
  – how it relates to important topics (health, environment, governance...)
  – give dramatic and concrete illustrations

Purpose

• A single statement or paragraph that explains what you intend to do
  – Method of investigation
  – Principle results of investigation
  – Principle conclusion(s) suggested by results

The goal of this study is to
  overcome the difficulty with ...
  discover what ...
  understand the causes or effects of ...
  refine our current understanding of ...
  provide a new interpretation of ...
  understand the relationship of...

To accomplish this...
Introduction

Significance of the Study

• Section (paragraph) creates a perspective.
• Point out how your study relates to larger issues.
• Uses persuasive rationale to justify your study.
• Explain why the purpose is worth pursuing.
• Answer...

Why is your study important?
To whom is it important?
What benefit(s) will occur from your study?
Introduction

Literature and Definitions

• Review of the literature
  – shows previous research
  – length depends upon research in your topic
  – If exploring a new area, cite similar studies that lead to current research
  – Never say that your area is so new that no research exists.

• Define when appropriate
  – *Operational* definitions you have formulated for the study
    
    *For the purpose of this research, improvement is operationally defined as post-test score minus pre-test score.*

  – abbreviations
    “An equal opportunity employer, M & F.” (NIH ad in *Journal of Virology*)
    Muscular and fit?
    Musical and funny?
    Mature applicant in his fifties?
Introduction

Research Question

Hypothesis

- Hypothesis – not a fact
  - Statement beyond the known to the next logical anticipation
  - Must fit the known information (cited literature)
  - Must be testable (experiment)

- Research question – requires an answer
  - clearly state without elaboration
  - what you are specifically going answer, determine, explain...

The research question for this study is, What are the attitudes of...

This study will determine if a cause/effect relationship exists between...
Meaning of Sources Vary

• Primary – *related directly* to topic
  – Field work and lab experiments
  – Photos, diaries, interviews
  – Cited literature

• Secondary – *about* a subject
  – Peer-reviewed journals
  – Avoid
    • Internet sources
    • General survey text books
    • Popular press (*National Geographic*)
Introduction
Mistakes

• Excessive background
  – Obvious and irrelevant
  – Information dump
  – Clouds rather than illuminates investigation

• Too much Methodology

• Too many Results
Although the water economies of a number of species of amphibians have been studied, the majority of these investigations have not been specific in nature (Smith et al., 1998). Such studies have often sought to elucidate adaptive differences among species (Schmid, 1965; Ralin and Rogers, 1972; Gillis, 1979). Although developmental stages of amphibians often occupy different habitats, corresponding changes in physiological parameters have been relatively unstudied.

The red-spotted newt (*Notophthalmus viridescens*) has a more complex life cycle than many amphibians. Following a brief larval development, these organisms metamorphose and become terrestrial salamanders, the red-efts. After spending up to seven years in this habitat, these sub-adults go through a second metamorphosis to become aquatic adults (newts) that spend the remainder of their lives in water (Conant, 1975).

In view of the difference in habitats occupied by these two stages it was hypothesized that newts and salamanders should differ in terms of their water economy. Specifically, terrestrial efts should have lower rates of evaporative water loss and be more tolerant to dehydration than aquatic newts.
Methodology

• Describe research plan
• Consists of
  – Population and sampling
  – Instrumentation
  – Procedure and time frame
  – Analysis plan (type of statistical tests)
    • Validity and reliability
    • Assumptions
    • Scope and limitations
Methodology

Population and sampling

Basic research paradigm:
1) Define the population
2) Draw a representative sample from the population
3) Study the sample
4) Infer your results from the sample back to the population

Population description: precise/concise single statement

*The population for this study is defined as*

- *carnivores in the region of...*
- *women in southern Uganda who...*
- *all economic communities in Asia influenced by fair trade policies.*
How to write Methodology

*What materials did you use?*

*How did you use them?*

- Past tense – passive, 3rd person
- Write carefully – no room for error
- Sampling procedures – detailed to replicate
- Scientific method *requires* that your results must be reproduced

*Samples were subjected to electrophoresis.* (Too little detail.)

- Avoid jargon and slang: *We ran the proteins on a gel.*
Social Science
Instrumentation

• If using a survey designed by someone else, state survey source.

• Explain theoretical constructs that the survey is attempting to measure.

  Attitude survey
  • Cognitive (think)
  • Emotional (feel)
  • Behave (action)

• Include a copy of the survey in the appendix
Results

- **Narrative** summary of data
- **Graphic** tables and figures
The key to Results

1. Present results in orderly sequence (of Methods)
2. If tables/figures summarize data, construct before writing
3. Interpret information in tables/figures

Results of the water quality analysis are shown in Table 1.
Nitrogen concentrations in runoff increased throughout 2010 (Table 1).

4. Present the facts: avoid discussion of results
5. Use statistical tests to support general statements.
6. Should stand out on its own
   – Nothing but results
   – All results you intend discuss later
How to write **Results**

*What did you discover?*

- **Figures and Tables**
  - Readable without text
  - Text reinforces important aspects of table and figure
  - One or two rows of data: write one or two sentences instead
- **Past tense**
- **Emphasize answer(s) to your question(s)**
- **Exclude results that are not relevant**
- **Supervisor looking for your ability to discriminate/interpret**
  - Filling pages with raw data does neither
  - End should easily draw to accept/reject hypothesis in **Discussion**
- **You may combine** **Results** and **Discussion**
Discussion

• Did results support hypothesis, answer research question?
• If hypothesis was refuted, provide an explanation
• Compare your results with others
  – Does your data agree with current models or refute them?
  – How has your investigation added knowledge?
How to write **Discussion**

*What do your findings mean?*

- Present tense
- Answer specific questions addressed in **Introduction**
- Show how your findings relate to existing knowledge
- Explain what is new, why your results are important
- Indicate what next steps might be
- Discuss possible errors or limitations of your methods
- Distinguish between facts and speculation
- Use end of the **Introduction** as your starting point
Conclusion

• Present tense
• Can combine with Discussion
• Strong summary
  – Last chance to reveal impressive insight
  – Restate the main idea of your Introduction
  – Summarize the sub-points, e.g.
    • State significance of Results/Discussion
    • Explain why readers should align with your position
  – Call for action or suggest future research
• Do not claim too much
Review Sample **IMRAD** Outline

**CHAPTER I – Introduction** *present tense*
- Statement of the problem & purpose
- Significance of the study
- Research questions and/or hypotheses

**CHAPTER II – Methodology** *past tense*
- Population and sampling
- Instrumentation (include copy in appendix)
- Procedure and time frame
- Analysis plan (type of statistical tests)
  - Validity and reliability
  - Assumptions
  - Scope and limitations

**CHAPTER III – Results** *past tense*

**CHAPTER IV – Discussion & Conclusions** *present tense*
- Summary (of what you did and found)
- Discussion (why you think you found what you did)
- Recommendations (based on your findings)

**REFERENCES**

**APPENDIX**
From Outline to First Draft

• Start with easiest, write simply
  – Methods or Theoretical Analysis
  – Results
  – Discussion/Conclusion (discuss with a friend)
  – Introduction

• Write Abstract

• Bury the first draft for a while
Abstract

Why did you start? (20-30%)
What did you do, and how? (10-20%)
What did you find? (35-45%)
What do your findings mean? (20-25%)

• One paragraph, generally 50-200 words
• Never refer to information not in the paper
• Avoid/define acronyms, abbreviations
Challenges

• Time management
• Outlining thoughts
• Writing skills
  – Insight via words
  – Quality not quantity
  – Clear, cohesive, concise