How to Write a Research Paper I

“Start with the Data”

The first in a series of V Lectures to help you prepare your Final Papers
But First…Consider

Science of Scientific Writing

If the reader is to grasp what the writer means, the writer must understand what the reader needs.

by George D. Gopen and Judith A. Swan

Article available on the 7.16 web site under writing instructor lectures.
Summary of the Science of Scientific Writing

Try to meet readers’ expectations.

Each unit of discourse serves a single function.

Put the action of the sentence in its verb.

“The cells were found to migrate.” vs “The cells migrated.”
Illustrations
Why might it make sense to begin your research paper by making the illustrations?
What’s the Purpose of Scientific Illustrations?
What’s the Purpose of Scientific Illustrations?

Tell a story

Condense large amounts of information and Simplify complex findings

Convince readers of your findings (by showing data quality or experimental design, apparatus)

Focus attention (e.g., relationship between values)

Promote thinking and discussion
Should the illustration be understandable without reading the rest of the paper?
Should the illustration be understandable without reading the whole paper?

Yes

That means the caption should contain sufficient information to interpret the data, including key aspects of the methods.
Name all the types of illustrations you think might be useful in the upcoming 7.16 papers.
What are Effective Graphics?

- Simple
- Clean
- Self explanatory
- Require a minimum of supplemental text

Total ink = Information ink
Example

Total Ink > Information Ink

This is straight out of Excel. See anything unnecessary?
Example Improved

The grey background provided absolutely no information and was unsightly. It’s what Tufte calls “chart junk.” But there’s more chart junk here.

Edward Tufte's Web Site (focus on visualizing data) http://www.edwardtufte.com/tufte/
Example Improved Again

Total Ink = Information Ink

- **Grid lines:** Your audience is unlikely to care about the exact values at each data point, and the grid lines compete with the data’s graphic pattern.
- **Legend:** Why make the reader look back and forth between lines and legend? Just label the lines - then eliminate the legend.
- **Axes:** The labeling between major tick marks is unnecessary.
### Table 1. Concentrations of total particulate matter, particulate calcium, and particulate aluminum in the upper 100 m of the Beaufort Sea.

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Sampling date (1989)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apr 10</td>
</tr>
<tr>
<td>10</td>
<td>49</td>
</tr>
<tr>
<td>25</td>
<td>83</td>
</tr>
<tr>
<td>50</td>
<td>132</td>
</tr>
<tr>
<td>100</td>
<td>24</td>
</tr>
</tbody>
</table>

**Total particulate matter (µg / liter)**

<table>
<thead>
<tr>
<th>Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

**Particulate calcium (µg / liter)**

<table>
<thead>
<tr>
<th>Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

**Particulate aluminum (µg / liter)**

**Figure 5.4**

Tables are the simplest visual format and preserve the original data. Each cell represents a full sentence. Tables do not, however, convey visual patterns and may hide significant events or trends.

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 Courtesy of The MIT Press. Used with permission.

When to Use Tables?

Use a table when repetitive data *must* be presented.

– Not for just a few determinations

– Not to report identical data

– Not to dress up your paper or oral presentation

This data should be presented in text:

“Aeration of the growth medium was essential for the bacterial growth. No growth was evident at room temperature (24°C) in stationary cultures, whereas substantial growth (D, 78 Klett units) occurred in shaken cultures.”

Why?
This data should be presented as text:

The oak seedlings grew at temperatures between 20 and 40°C; no measurable growth occurred at temperatures below 20°C or above 40°C.
Beware of plus and minus signs. This table simply says:

“S. griseus, S. coelicolor, S. everycolor, and S. rainbowenski grew under aerobic conditions, whereas S. nocolor and S. greenicus required anaerobic conditions.”
How to Arrange Tables?

Arrange data so like elements read:
- down (fig 7)
- not across (fig 6)

To illustrate, try adding numbers across.

Source: Tables 6 and 7, Chapter 13, in [Day 1998].
Graphs

(a) Correlation, (b) Rate of Change, (c) Frequency, (d) Net differences

Figure 5.11
Some common varieties of analytical graphs.

Courtesy of The MIT Press. Used with permission.
When to Use Graphs?

Use graphs to present data in an organized way...not to dress it up

Don’t express the same data in both a table and a graph

Courtesy of The MIT Press. Used with permission.
When to Use Graphs versus Tables

Image removed for copyright reasons.

Source: Table 9 - Chapter 1 and Figure 2 - Chapter 14, in [Day 1998].

Table 9 and Figure 2 present the same data, which one is better?
Among the test group of 56 patients who were hospitalized for an average of 14 days, 6 acquired infections.
What’s Wrong with these Graphs?

Image removed for copyright reasons.

Source: Figure 4, Chapter 14, in [Day 1998].
A Good Graph

Lettering large enough to withstand photographic reduction.

Sides are boxed rather than two-sided so right-hand values are easy to estimate.

Scribe marks point inward

Caption:
Concise title
Defines symbols
Provides information pertinent to data interpretation
Provide Textual Context for Illustrations

METHODS:
Describe experimental design or apparatus, and refer to an illustration for additional details.

RESULTS:
Say what the data show or indicate.
Say how the illustration supports, clarifies, or summarizes your findings.

DISCUSSION
Why is that data important?
What does the data mean?
How does it support your argument, theory, or hypothesis?
What are Some Pitfalls of Tables, Graphs, and Captions?

Tables and Graphs:
- Not mentioned in text
- Inconsistent with text
- Mislabeled
- Unreadable or cluttered
- Ugly

Caption:
- Data interpretation requires reference to the paper
- Reiterates results section
- Written in shorthand rather than whole sentences
Good Luck