

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 □

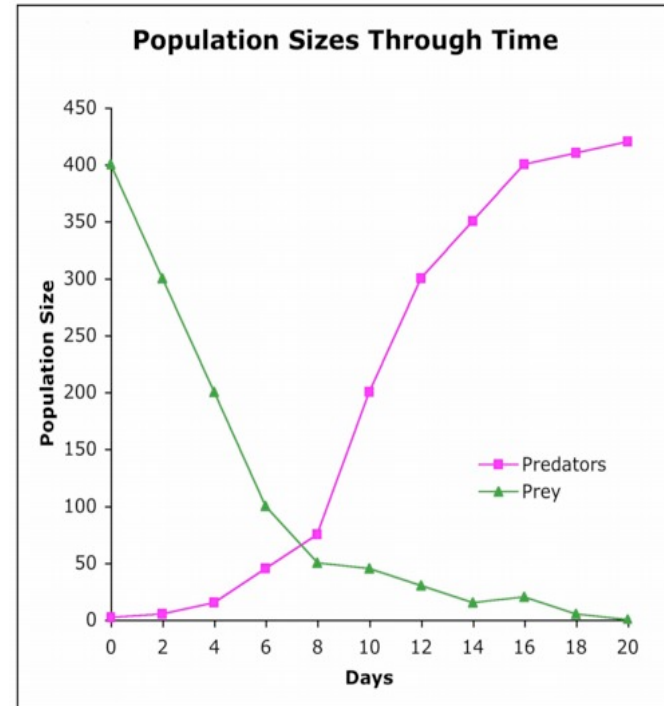
Example

Total Ink > Information Ink



This is straight out of Excel. See anything unnecessary?

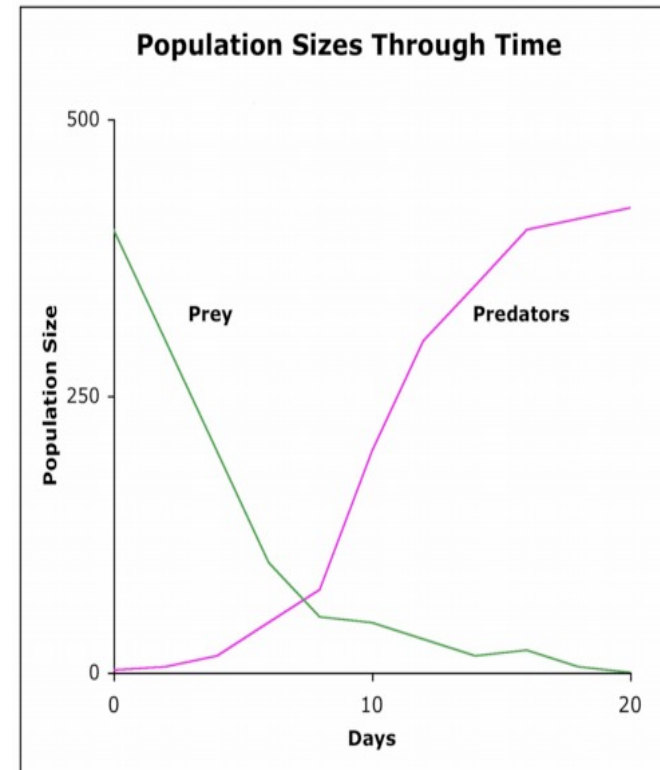
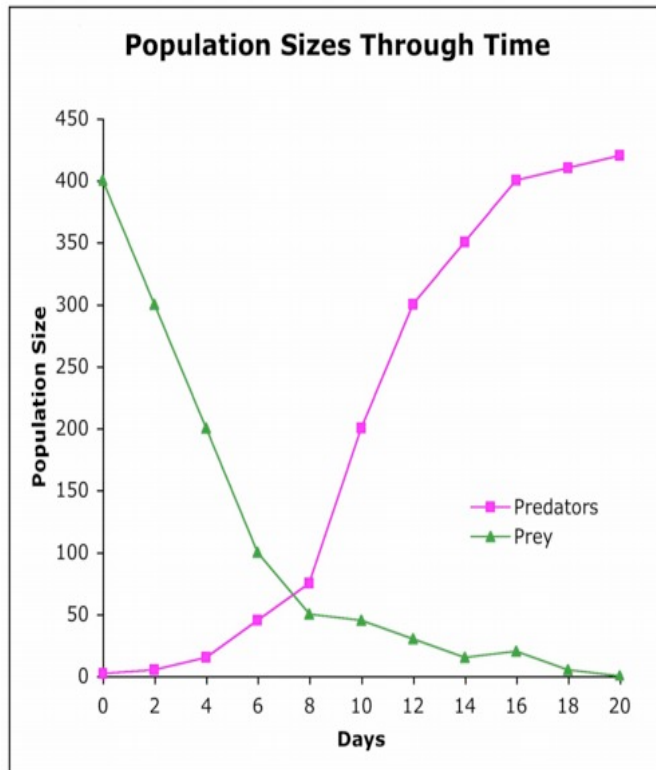
Example Improved



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

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.

Tables

Note that the Table number and title appear ABOVE the Table, not below

Heading

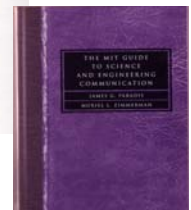
Table 1. Concentrations of total particulate matter, particulate calcium, and particulate aluminum in the upper 100 m of the Beaufort Sea.

Depth (m)	Sampling date (1989)											
	Apr 10	20	30	May 10	20	30	Jun 9	19	29	Jul 9	19	
Columnhead	Total particulate matter ($\mu\text{g} / \text{liter}$)											
Stubhead	Particulate calcium ($\mu\text{g} / \text{liter}$)											
Column	10	49	180	129	86	45	37	38	61	61	44	60
	25	83	116	72	78	105	19	30	68	46	44	37
	50	132	108	131	77	43	28	32	19	48	34	36
	100	24	20	52	52	28	18	21	25	32	24	26
Row	Particulate aluminum ($\mu\text{g} / \text{liter}$)											
Cell	10	2.3	11.2	5.4	5.4	0.3	0.3	2.2	2.6	5.4	2.4	3.1
	25	3.1	9.1	3.3	3.3	2.4	0.2	1.5	0.8	4.4	2.5	2.5
	50	10.5	3.3	3.1	3.1	0.8	0.2	2.1	1.3	4.3	2.6	2.6
Rowstub	100	2.5	16.8	1.5	1.5	0.5	0.1	3.3	3.7	3.1	1.2	3.1
	10	0.16	0.34	0.29	0.99	0.31	0.48	0.14	0.18	0.12	0.10	0.14
	25	0.12	0.27	0.21	0.88	0.50	0.19	0.13	0.44	0.10	0.13	0.10
	50	0.19	0.82	0.17	0.17	0.18	0.10	0.93	0.07	0.05	0.05	0.09
	100	0.08	0.21	0.04	0.06	0.09	0.17	0.62	0.12	0.60	0.92	0.08

Additional information e.g., footnotes, abbreviations Appear BELOW the table

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.



Courtesy of The MIT Press. Used with permission.

Source: Paradis, James G., and Muriel L. Zimmerman. [The MIT Guide to Science and Engineering Communication](#). Cambridge, MA: MIT Press, 1998.

When to Use Tables? □

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

– Not for just a few determinations

Source: [Day 1998] Day, Robert A. *How to Write and Publish a Scientific Paper*.
5th ed. Phoenix, AZ: Oryx, 1998. ISBN: 1573561657.

– Not to report identical data

– Not to dress up your paper or oral presentation

Useless Table #1

Note proper form for
Tables; table number
and title ABOVE,
Explanation of symbols
BELOW

Image removed for copyright reasons.

Source: Table 1, Chapter 13, in [Day 1998].

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?

Useless Table #2

Image removed for copyright reasons.

Source: Table 2, Chapter 13, in [Day 1998].

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.

Why?

Useless Table #3 □

Image removed for copyright reasons

Source: Table 3, Chapter 13, in [Day 1998].

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.

Image removed for copyright reasons.

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

Graphs

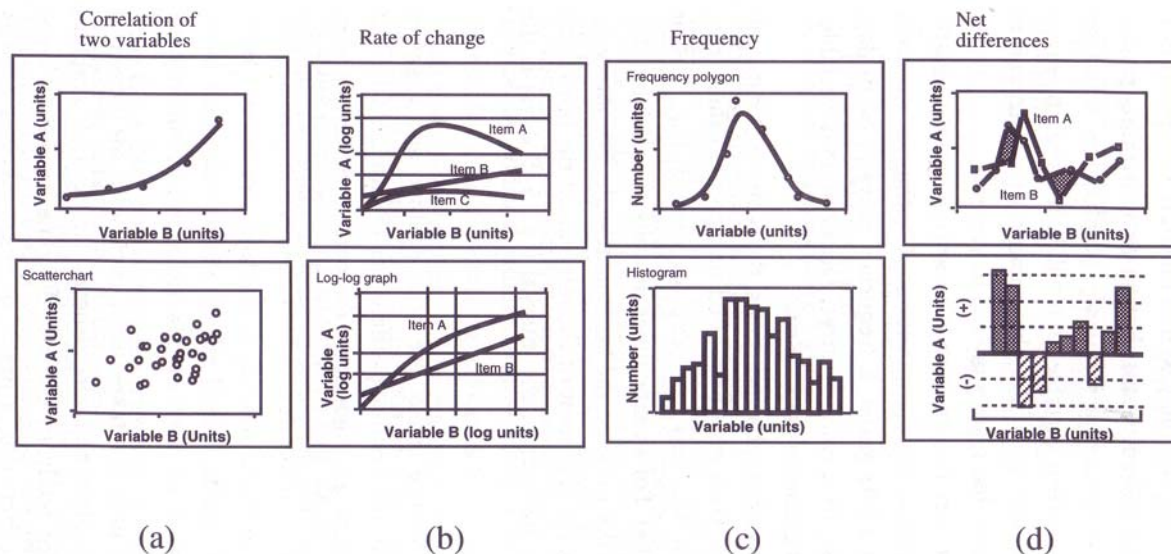


Figure 5.11
Some common varieties of analytical graphs.

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

Courtesy of The MIT Press. Used with permission.

Source: Paradis, James G., and Muriel L. Zimmerman. [The MIT Guide to Science and Engineering Communication](#). Cambridge, MA: MIT Press, 1998.

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 □

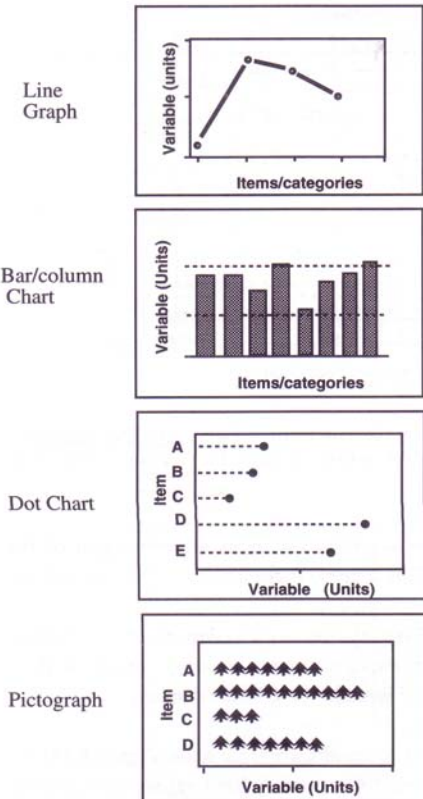


Figure 5.8
Items with different values.

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?

Useless Graph

Image removed for copyright reasons.

Source: Figure 1, Chapter 14, in [Day 1998].

This useless bar graph should be presented in text:

“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.

Image removed for copyright reasons.
Source: Figure 3, Chapter 14, in [Day 1998].

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 ☐