

Writing Research Papers

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General Principle

- Gather data
 - Introduce the experiment: Why are you doing this?
 - Describe the result/finding: What next important question is raised?
- Put together figures and tables
 - Give each figure/table a simple, declarative title in the form of a sentence
- Decide if you have a story and a bottom line (selling point)
 - A strong paper/complete story needs:
 - a discovery
 - some mechanism
 - broader implications

General Principle

- Write a provisional title to express the bottom line
 - Include key components in the title
- Outline result section
 - Based on the order of Figures and Tables
 - Logical order: telling a story
- Keep focused on the bottom line
 - Exclude everything that does not contribute to that bottom line
- Keep the logic flowing. Leave no gaps
 - Bullet main ideas
 - Convert main ideas into topic (or summary) sentences

Submitting Principle

- The journal's scope and goals: read instructions to authors
- Target audience: broad or specialized?
- Ways of presentation:
 - Simple or complex take-home message?
 - How many figures and tables?
 - Should Results/Discussion be combined?
- Where were similar papers published? (Journal Citation Reports)
- Who will manage the review?
- Ask others to help assess the degree of novelty in your work; Ask them to be critical
- Start from journals with higher rank/impact factor

General Structure

- An objective of organizing a research paper is to allow people to read your work selectively
 - Do NOT read from the first word to the last word
- Sections of a research paper
 - Title (Cover page)
 - Abstract
 - Introduction
 - Materials & Methods
 - Results
 - Discussion
 - References

Writing Order

- Figures (Figure legends) and Tables
- Title (Cover page)
- Materials & Methods
- Results
- Introduction
- Discussion
- References
- Abstract
- Put the draft in drawer several days. Revise from beginning to end
 - Acknowledgments
 - Cover letter
 - Rebuttal letter

Figures and Tables

- Fig. and Tables are backbone of a manuscript
- Every Figure and Table should have a clear point
 - Use the clear point as the first sentence of the Figure legend and Table caption (legend)
 - Any Table or Figure must be able to stand alone and be interpretable
 - sufficiently clear, well-labeled, and described by its legend to be understood by audience without reading the results section
- Place of the legend
 - Table legends go above the body of the Table and are left justified
 - Figure legends go below the graph
- Tables and Figures are put on separate pages from text material and at the end of manuscript

Things to be noticed in making Tables

- Figure and Table number consistent with text
- The presence of a period after “Table #.”
- Arabic numbers are easier to read than Roman numbers (1,2,3... vs. I. II. III....)
- Upper-lower case type is easier to read than all upper case letters (Tables vs. TABLES)
- Arrange comparisons vertically
- the numbers you want to compare are close to each other
- Units are specified in column headings wherever appropriate

Things to be noticed in making Tables

- Lines of demarcation are used to set (1) legend, (2) headers, (3) data, and (4) footnotes apart from one another
- Avoid vertical lines between columns
- Make the contents concise
 - Round data to simplify: use common units
 - Avoid repetitive information
- Footnotes are used to
 - Clarify points in the Table
 - Convey repetitive information about entries
 - Denote statistical differences among groups
- Self-contained, to stand alone

The Anatomy of a Table

Table legend

Table 1. Control of a first-planting corn stand as influenced by herbicide treatment and corn growth stage.

Column titles

<i>Treatment</i>	<i>Rate</i>	<i>% control^a</i>	
		<i>V1 at time of application</i>	<i>V2–V3 at time of application</i>
Liberty	32 fl oz	50	75
Gramoxone Inteon	2.25 pt	27	48
Gramoxone Inteon	2.50 pt	— ^b	40
Gramoxone Inteon + Sencor	2.25 pt + 3 oz	65	—
Gramoxone Inteon + Sencor	2.50 pt + 3 oz	—	70
Balance Pro + atrazine	3 fl oz + 1 lb	—	25
SelectMax	1 fl oz	12	33
SelectMax	2 fl oz	58	68
SelectMax	3 fl oz	—	75
SelectMax	4 fl oz	98	94

Table body

Footnotes

Data averaged over experiments conducted in 2006 and 2007.

^aControl ratings taken 14 days after herbicide application.

^bNot all treatments were applied at each corn growth stage.

Things to be noticed in making Figures

- Consistent scale, boldness, and font (Adjust in Illustrator)
 - a good rule of thumb in Fig. size: about one-half of a page
- Avoid “busy” figures and “white space”
- Avoid using a title for Figures
- Avoid using unnecessary boxes (especially with heavy lines) to enclose graphs or images
- Most often black and white is preferred
 - Photocopy or fax your paper, any information conveyed by colors will be lost
 - Very expensive in publishing color figures
- Always include error bars (SD or SEM) when plotting means
- Understood independently, to stand alone
 - Figure legend goes below the figure and conveys all the necessary information

Things to be noticed in making Figures

- **Capitalization**
 - Sentence-style capitalization within figures
- **Font sizes**
 - 6 ~ 13 points (Exception: 16-point panel labels [A, B, C])
 - Font styles and sizes should be consistent throughout figures
 - All fonts must be legible at actual print size
- **Scientific notation**
 - P values (probability) are capital and italicized (e.g., $P < 0.01$)
 - r values (bivariate correlation coefficient) are lowercase
 - R values (multivariate correlation coefficient) are capital

Bar Chart

- Bar graphs used to compare the value of a single variable (usually a summary value such as a mean) among several groups
 - a period follows "Figure 1" and the legend itself; "Figure" is not abbreviated
 - the categorical variable is labeled on the X axis
 - Bars in logical (chronological) order
 - the measured variable is labeled on the Y axis with units
 - All bars the same width
 - Avoid “stacked” effect

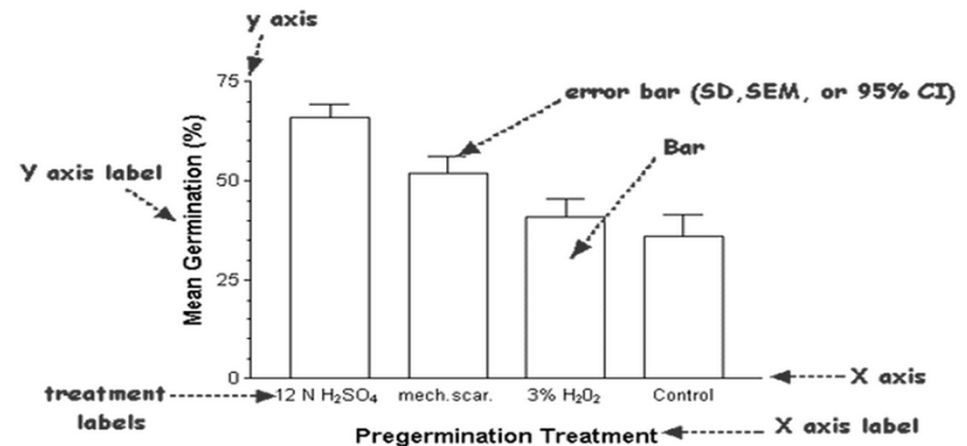


Figure 1. Mean germination (%) (+SD) of gourd seeds following various pregermination treatments. N=10 groups of 100 seeds per treatment and control. Treatments: 12 hour soak in 12 N H₂SO₄, 90 second scarification of seed coat with 80 grit sandpaper, 6 hour soak in 3% H₂O₂.

Bar Chart

- Include error bars (SD or SEM) above the mean
- Indicate statistical differences by a system of letters (e.g., * [asterisk], **, etc.) above the bars, with an accompanying note in the legend indicating the test and the significance level used
- Avoid 3-D bar charts, unless necessary
- Y axis: ordinate; X axis: abscissa

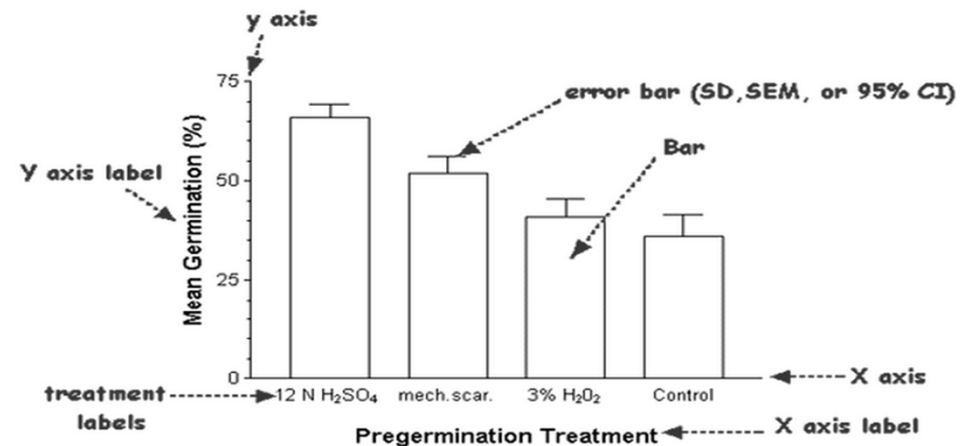


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14

figure legend

Line Graph

- Use a line graph to compare responses
 - depict a change in Y as a function of X
- Put time or levels on horizontal axis
- Avoid more than three lines on a graph
- Connect points for continuous data
- Do not put dis-continuous data in line

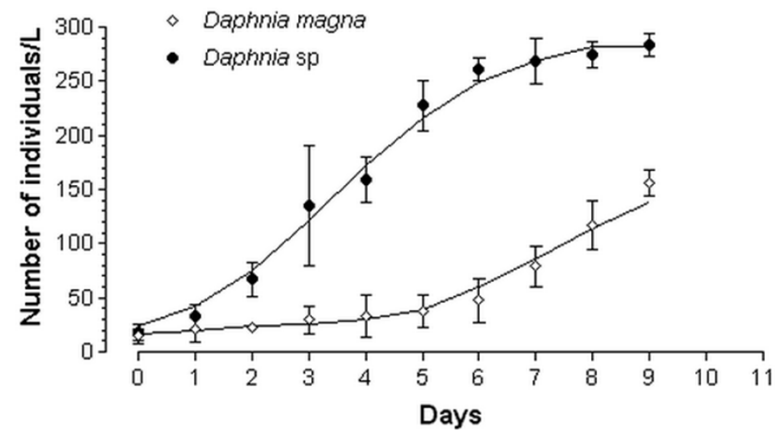


Figure 2. Mean population density (± 1 standard deviation) of two species of *Daphnia* following artificial eutrophication of a small farm pond by application of organic fertilizer. Six replicate 1 L water samples were drawn from 50 cm depth at 1100 hr each day.

Line Graph

- Different symbols are used for each group
 - The key to the symbols is placed in the body of the graph where space permits
- Symbols are large enough to be easily recognizable in the final graph size
- Each point represents a mean value, and this is stated in the legend
- Error bars are for each point and defined in the legend

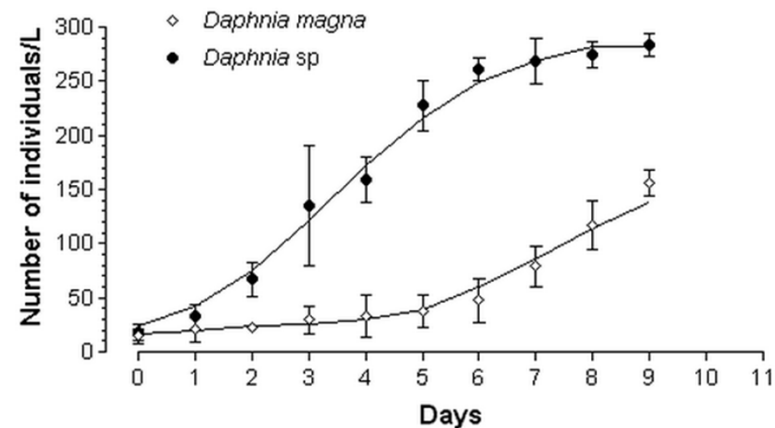


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Scatter Plot

- Use a scatter plot to show correlation between two variables
- The range of each axis: to maximize the spread of the points and to minimize wasted blank space

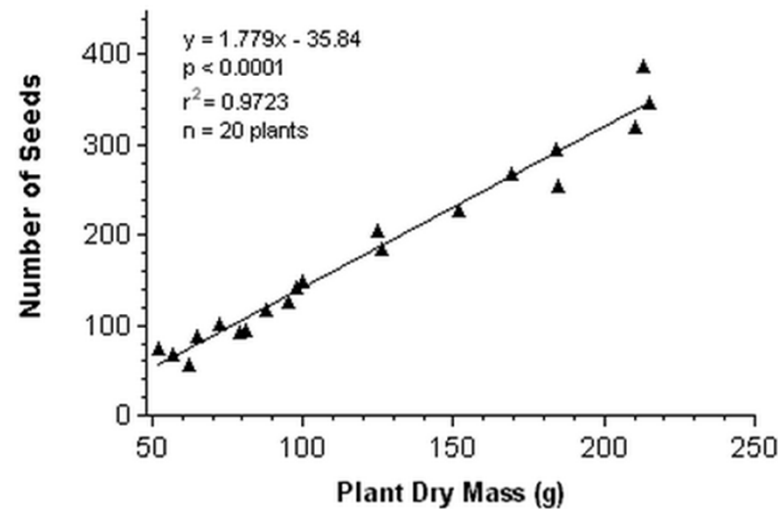
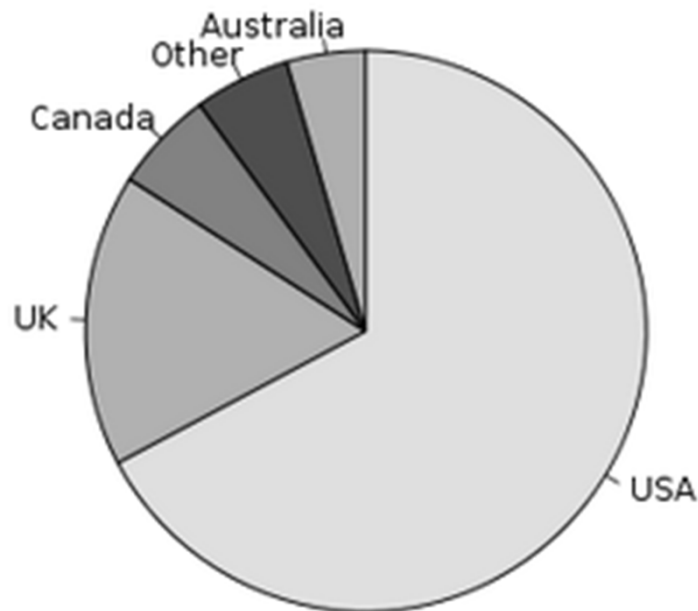


Figure 3. Seed production as a function of plant biomass in waterlilies (*Nuphar luteum*) harvested from Great Works Pond in Northern Maine in August, 2001.

Pie Chart

- Use a pie chart to compare a part to the whole
 - Start at 12:00 with largest segment
 - Limit segments 5-7
 - Label segments outside the circle



Fraud: Don't do it!

- Photoshop makes fraud easier to commit but also easier to detect
- Fraudulent results can't be repeated. Even if not "caught," suspicion will hang over you
- Creating a result is worse than making weak data look better
- Any benefit from "cleaning up" your results is not worth the damage to your reputation

Image Manipulation Principle

- If evidence of inappropriate image manipulation is detected, the Journal's Editors will ask for the original data
- Unacceptable manipulations include adding to, altering, moving or removing of a specific feature of an image
- The splicing of multiple images to suggest they represent a single micrograph or gel is not allowed
- The same data should not be presented in multiple figures, unless explicitly stated and justified
- Molecular weight markers must be indicated on all images of gels and blots

Image Manipulation Principle

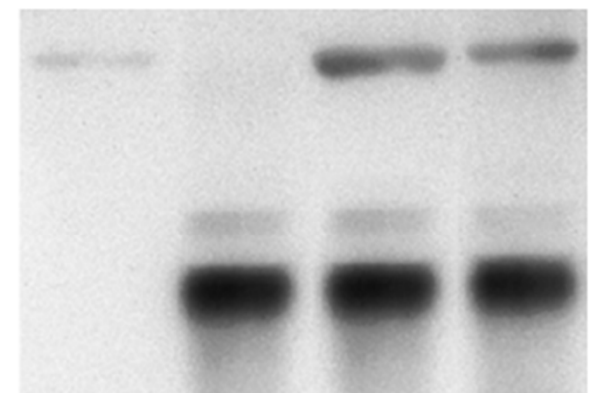
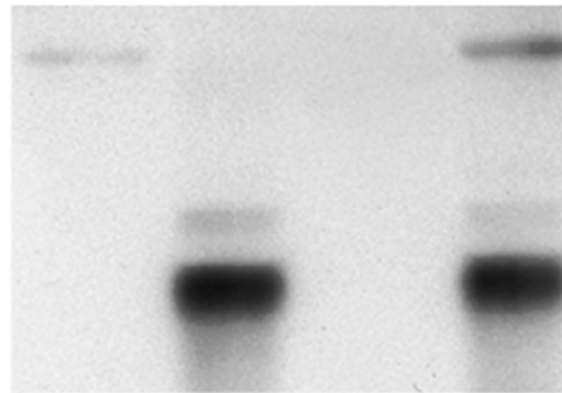
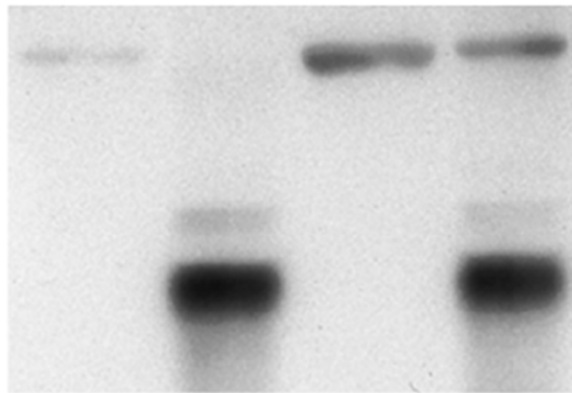
- Adjustments applied to the whole image are generally acceptable if no specific feature of the original data, including background, is obscured, eliminated or misrepresented as a consequence
- Any grouping or consolidation of data (e.g. removal of lanes from gels and blots or cropping of images) must be made apparent (i.e. with dividing lines) and should be explicitly indicated in the figure legends
- Previously published data should not be presented, unless explicitly stated and justified. Proof of copyright permission from the original publisher must also be provided
- All figures containing micrographs must contain a scale bar

A

Original image

Manipulated image

Manipulated image



1

2

3

4

1

2

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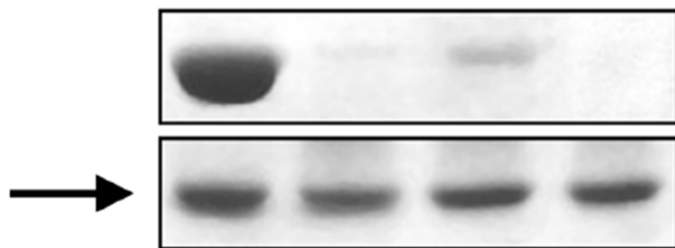
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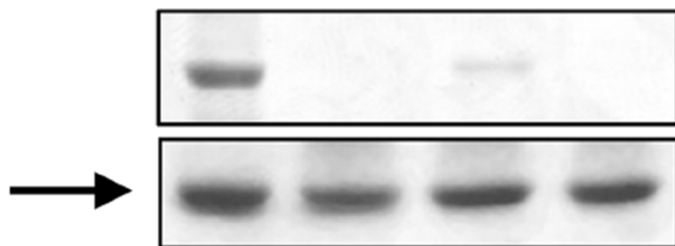
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Experimental A

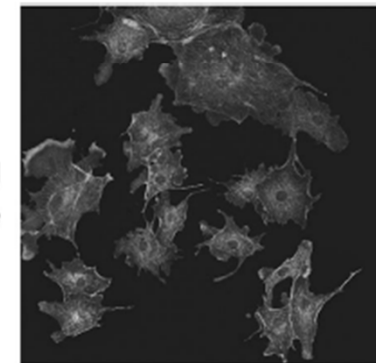
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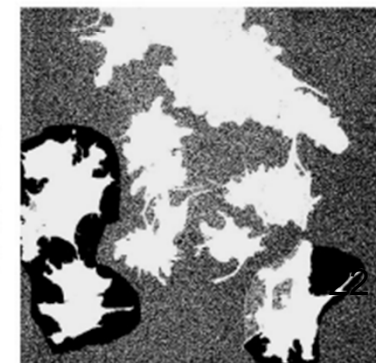
Experimental B

Loading control B

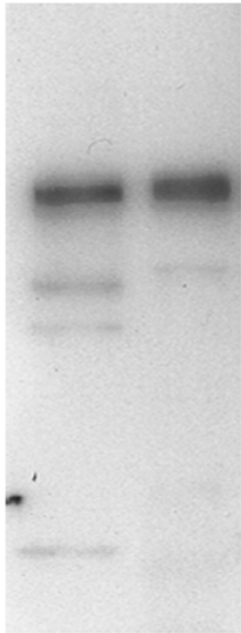
Manipulated image



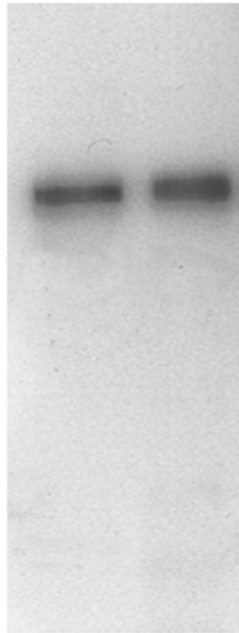
Manipulation revealed by contrast adjustment



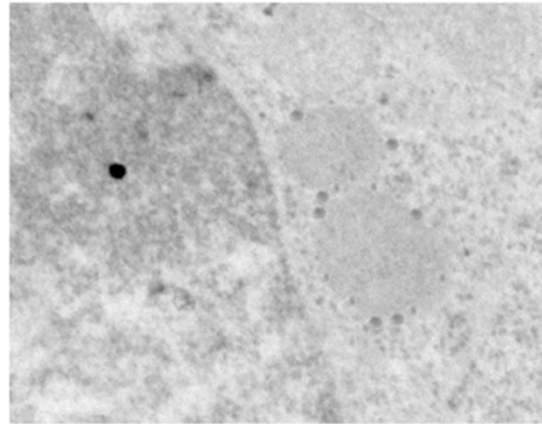
Original image



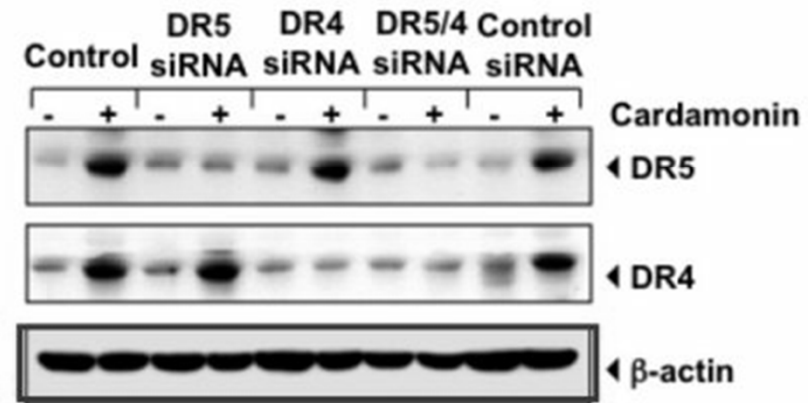
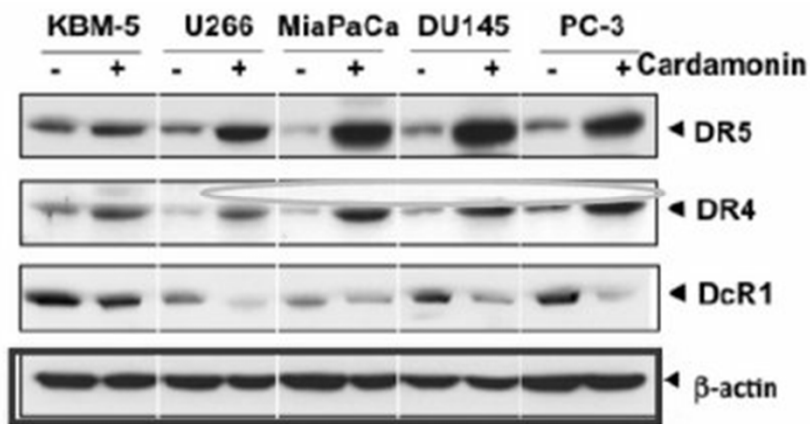
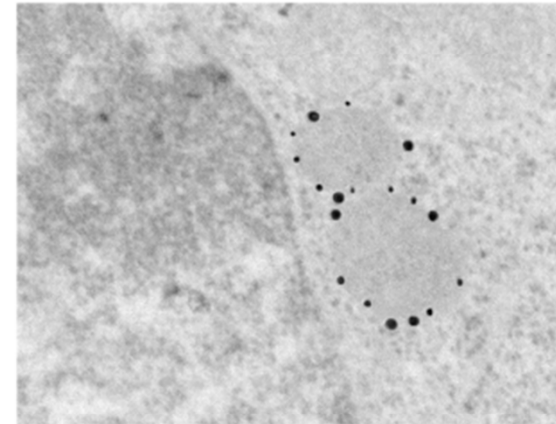
Manipulated image



Original image



Manipulated image



Title

- Title must reflect the central theme: selling point
 - Including key components
- Attractive and easy to understand
- Concise and Informatiive: avoid no noninformative words like “A study of---”
- Avoid acronyms

Materials and Methods

- Buy materials before doing experiments → materials, then methods
- Only describe methods used
- Include enough information, but not more than necessary
→ Rule of thumb: the research can be repeated
- Keep it extremely brief unless describing an unusual technique
 - e.g., ... according to the manufacturers' instructions
- Include rationale for why an experiment was done a particular way

Results

- Tell a story. Follow your story line
 - Lead with important result, follow with controls and secondary findings
 - Chronologically
- Topic sentence: Lead each paragraph with the experimental aim and primary result. Then elaborate it.
- One paragraph = one thought
- Describe why you are moving from one experiment to another
- Don NOT interpret the data or draw major conclusions

How to refer to Tables and Figures from the text

- Every Figure and Table included in the paper MUST be referred to from the text
 - When referring to a Figure in the text, the word "Figure" is abbreviated as "Fig."
 - "Table" is not abbreviated
 - Both words are spelled out completely in descriptive legends
- Numbers/data mostly in the figures. Don't bury the reader in numbers
- Do not repeat numbers from the tables, but do integrate data with the text

How to refer to Tables and Figures from the text

- Use sentences that draw the reader's attention to the relationship or trend you wish to highlight, referring to the appropriate Figure or Table only parenthetically:
 - Germination rates were significantly higher after 24 h in running water than in controls (Fig. 4).
 - DNA sequence homologies for the *purple* gene from the four congeners (Table 1) show high similarity, differing by at most 4 base pairs.
- Avoid sentences that give no information other than directing the reader to the Figure or Table:
 - Table 1 shows the summary results for male and female heights at Bates College.

Introduction

- Funnel from the broad background (the big picture, significance of the field), to specific gaps (still unknown) , to questions answered by bottom line (selling point)
- Previous studies: General background information to the key components in the title; What has been done
 - Think of the terms in which you would justify your work to your parents
 - NOT a literature review. You are setting up the question
 - State what has NOT been done
- “Therefore” → State objectives, hypothesis, and approach
- Finish with a very brief summary of the results and why they are important

Introduction: Problems

- Too little or irrelevant background information
- Information not updated
- Unclear purpose; no rationale for the study
- Disorganization in logic

Discussion

- Start with bottom line with a very brief (1-3 sentence) summary
- Do not just copy and paste results!
- Subsequent points go from most important / most related to bottom line to least important / least related
- Interpret results and support conclusions with evidence from the literature
- One paragraph = one thought

Discussion

- Be Specific and Precise
 - Don't just cite references, but describe
 - Watch out for lazy thoughts and stock phrases
 - Not “gives insight into...” but “shows that process X uses mechanism Y.”
 - Not “opens up new ways of tackling disease X” but “suggests that approach Y will work against disease X.”
- Distinguish between confirmatory and new, and established and speculated
 - Make all links. A link that is obvious to you will not occur to many of your readers
- Discuss different levels of significance
- Describe limitations of your research

References

- Use software: e.g., EndNote
- Follow the instructions of journal
- Should correspond to the text
- Updated; don't miss the most relevant ones
- Consistent format

Abstract

- First impression to the readers and editors
- Write it last, following the logic of the paper
- Summarize key points in the paper:
 - 1-2 sentences:
 - Give essential background
 - 2-3 sentences:
 - State results
 - 1-2 sentences:
 - State conclusion, and significance /implications of findings
- Check character/word limits on Abstracts: often <150-200 words

Acknowledgments

- General acknowledgments:
 - Institution or lab
 - Research project
 - Source of funds
- Specific acknowledgments:
 - Colleagues & technicians
- Examples:
 - We thank Drs. Xxx (institute), and xxx for support in ... [for critical reading of the manuscript.]
 - The project was financially supported by xxx
 - We are grateful to xxx for ...
 - XXX was supported by ...
 - This work was supported by ... to xxx

General Format

- Print or type using a 12 point standard font, such as Arial, Times New Roman, Helvetica, etc.
- Text should be double spaced with 1 inch margins, single sided
- Number pages consecutively
- Start each new section on a new page
- Adhere to recommended page and word limits
- Italicization: foreign words and phrases that have become a part of the English language need not be italicized
 - e.g., *in vitro*, *in silico*, *in vivo*, etc.

General Format: Space Issues

- Spacing in equations: a space before and after symbols such as addition (+), subtraction (-), greater than (>), less than (<), and equal to (=), e.g., $a + b = c$
- Spacing when showing values: Arithmetic symbols to show the sign or value of a number, a space should not be inserted, e.g., -5, >10
- Spacing between a numeral and unit: e.g., 50 cm
 - Exception: 50%

Tense

- Abstract: As a summary of work done, it is written in past tense
- Use Past Tense:
 - reflect work that has been completed
 - referring to the *actual work* that you did, including statements about your expectations or hypotheses
 - referring to the work of others that you may cite
- In all sections of the paper, present tense only used to report background that is well accepted facts

Choice of Words

- Use words that are accurate → say what you mean
- Use words that are appropriate → fit well with other words
- Use words that are familiar → easy to read and understand
- Avoid jargon, use plain language
- Do not use colloquial speech, slang, or "childish" words or phrases

Choice of Words: Number

- Spell out numerals from one through nine
- Use numerals for 10 or larger
- Spell out numbers at the start of a sentence, but avoid if possible
- Use a word for a large number that ends with many zeros (16,000,000 vs. 16 million)

Choice of Words: Abbreviation

- Spell out the full name of abbreviation for the first time, then the abbreviation in parentheses; e.g., non-small cell lung cancer (NSCLC)
- Abbreviate units of time when used with a number: yr, mo, wk, d, h, min, s
 - Unit symbols are unaltered in the plural (e.g., 10 cm)
 - No period unless at the end of a sentence; NOT 10 cm.
- Do not use contractions: e.g., "don't" must be "do not"; "isn't" must be "is not"; cannot vs. can not
 - You cannot do it. 你不能做
 - You can not do it. 你不能做/你能不做

Abbreviation

Abbrev.	Full term
app.	Appendix
cf.	(<i>confer</i>) compare
ch.	Chapter; plural chaps.
col.	Column; plural cols.
e.g.	(<i>exempli gratia</i>) for example; He ate fruits, e.g., apples and oranges.
esp.	Especially
et al.	(<i>et alii, aliae, or alia</i>) and others; e.g., Smith et. al.
et seq.	(<i>et sequens</i>) and the following; e.g., p.23 et seq.
etc.	(<i>et cetera</i>) and so forth; He ate bread, butter, etc.
ibid.	(<i>ibidem</i>) in the same place: from the source previously mentioned
i.e.	(<i>id est</i>) that is
inf.	(<i>infra</i>) below: refers to a section still to come
l.	Line; plural ll.
p.	Page; plural pp.; e.g., p.15
para.	Paragraph; plural paras.
vol.	Volume; plural, vols.

Sentence Structure

- Make the topic the subject
- Use the active voice: shorter, clearer, more interesting, more direct; Put the action in the verb
 - An increase in heart rate occurred.
→ Heart rate increased.
- Put the main idea of your sentence into the subject and verb
 - There were a great number of dead leaves lying on the ground.
→ Dead leaves covered the ground.
- Avoid long noun clusters
 - Keep sentences short and simple
- Keep related words (e.g., subject and verb) together

Sentence Structure

- Talk about one thing at a time
- Use parallel constructions
 - It was both a long talk and very tedious.
→ The talk was both long and tedious.
- Less is always more. Don't use more words than needed. Be precise.

Paragraph Structure

- One paragraph = one thought
- A summary of this thought is the first (topic) sentence
- Elaborate from this in a logical order
 - pro then con
 - most to least important evidence
 - chronological
- Be direct and specific - tell what did actually happen
- Make logic clear: use transition words to link ideas
- Tell the reader what to expect
 - There are two problems with this method: X and Y.
Problem X ..., and problem ...

Paragraph Structure

- Start with “old” information [topic position], end with “new” information [stress position].
 - After insemination, spermatozoa are stored in the hen and slowly released. After release, spermatozoa are captured....
 - Put conditional ideas at the beginning of the sentence
 - For Breed A, waning weight was lower for calves on Diet 1 than on Diet 2.
 - Use the same organizational pattern for successive sentences
 - Use parallel structure for the main subjects and main verbs
 - Smoother writing; more forceful; easier to understand

Problems With Writing

- Too long sentences and paragraphs
- Look out for long and dubious parentheses
- No logical connection among paragraphs
- Not explain specific terms clearly (readers probably are not in your field)
- acronyms and jargons
- Misspelling; check with Word program
- Grammar errors; check with Word program
- Chaotic format: inconsistency
- Wrong grammar (singular vs. pleural)

Paraphrase, NOT Plagiarism

- **Plagiarism** (use of others words, ideas, images, etc. without citation) is not to be tolerated
 - Copy and paste is not acceptable
 - Add quotation mark "...", if copy and paste
 - Avoided by adequately referencing any and all information you use from other sources
- **Paraphrase:** a restatement of the meaning of a text or passage using other words

Revising

- Set aside the paper for several days
- Look for logical gaps and inconsistencies
- Cut ruthlessly. Use simple, direct constructions
- Style: Yes to simplicity; no to verbosity
 - Use, don't utilize
 - Chop everything from single words to entire paragraphs
 - Repeat only the bottom line
- Is it worth creating a 20-page masterpiece if no-one will read it?
 - Shorter sentences/ paragraphs/ papers are clearer
- Have others read the paper and give written comments

Sending the Manuscript

- Write a cover letter that is short, gives context, says what is new, and is addressed to the right journal
- Remember your audience and be concise
- An editor is a generalist: Clearly state the significance and implications of your findings
- Put them in a bigger context

Responding to Reviews

- Don't take it personally
- Assume the referees are experts. If they didn't understand, you didn't communicate effectively
- Fix or modify, even if you don't fix in the suggested manner
- Write a cover letter with resubmission that acknowledges and responds to the referees
- Admit it if you chose the wrong journal