



**Guidelines for  
Preparation & Presentation of  
Student Research**

# Contents

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This booklet has been prepared as a general guide to writing a research paper for submission to the Junior Science & Humanities Symposium (JSHS).

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Revised 1997, 1998 by Linda Martin.

# The JSHS Research Paper

**Definition** The **JSHS research paper** is a written report describing original research results in science, mathematics, or engineering. The paper should rely on previously published literature primarily for background and comparative purposes.

- Contents** The typical JSHS paper is organized as follows:
- title page, or cover page
  - abstract
  - acknowledgments
  - table of contents
  - list of tables and/or list of figures
  - introduction
  - materials and methods
  - results
  - discussion and conclusions
  - references, or literature cited
  - appendices (optional)

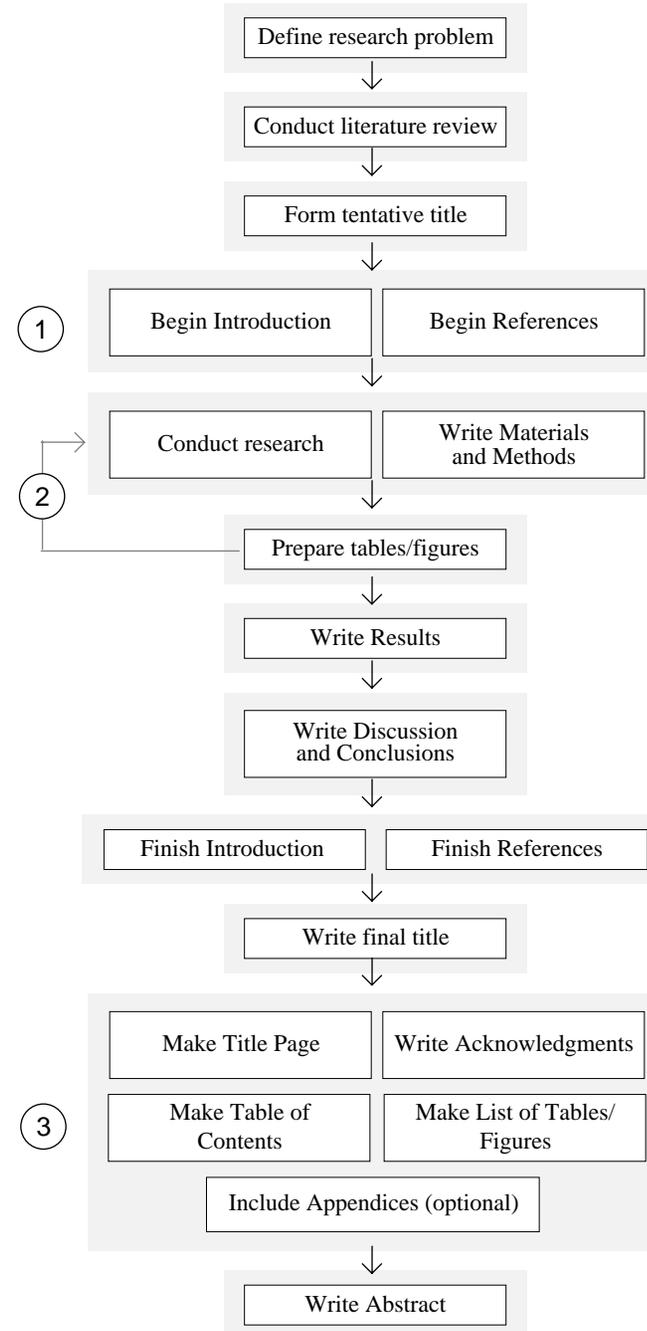
**Comment** **Please format according to JSHS guidelines.** The format for an JSHS paper differs somewhat from a paper submitted to science fair.

- **Do not** add separate sections entitled Purpose, Hypothesis, and Review of Literature—include that in the Introduction.
- **Do not** include forms from other science competitions, e.g., Safety Sheet.
- **Do not** include your name in headers /footers on each page.

**Sequence** See page 2 for a suggested sequence for conducting the research and writing the paper. Side-by-side blocks indicate concurrent actions. The following comments correspond to numbers on page 2:

- ① Begin writing the Introduction after you conduct your literature review. You will not *complete* the Introduction, however, until later in the sequence. As you cite sources throughout your paper, add them to the References section.
- ② When preparing tables or figures, you might notice gaps in your data. If so, return to the experimental mode and collect the missing data.
- ③ Completed in any order.

# Sequence



## Title

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|                     |   |
|---------------------|---|
| <b>Introduction</b> | In scientific writing, the title is always intended to <i>convey information</i> . Scientific writing is <i>not</i> creative writing, nor advertising. A good <i>scientific</i> title simply orients the reader to the content of your paper in the fewest words possible.  |
| <b>Definition</b>   | The <b>title</b> is a concise identification of the main topic of the paper.  |
| <b>Description</b>  | A title is: <ul style="list-style-type: none"><li>• concise,</li><li>• descriptive, and</li><li>• informative.</li></ul>  |
| <b>Rules</b>        | When writing a title: <ul style="list-style-type: none"><li>• <b>do not</b> write the title as a question;</li><li>• <b>do not</b> use abbreviations.</li><li>• avoid "excess" words such as <i>a</i>, <i>an</i>, or <i>the</i>, or phrases such as <i>a study of</i> or <i>investigations of</i>.</li><li>• consider its length. A two or three word title may be too short, but a 14 or 15 word title is probably too wordy.</li></ul>  |
| <b>Example</b>      | <p><i>Poor:</i> Bugs and Drugs<br/><i>Fair:</i> Effects of Antibiotics on Bacteria<br/><i>Good:</i> Effects of Penicillin on Gram Negative Bacteria<br/><i>Best:</i> Lysis of Gram Negative Bacteria by Penicillin</p> <p>The first example is concise, but neither informative nor descriptive. It is not scientific style. The second example is concise but too general. What effects? What antibiotics? What bacteria? The third example is more specific, both in describing the antibiotic and the bacteria, but it still lacks description. The fourth example is written in scientific style.</p> |
| <b>Sequence</b>     | A tentative title can be written after the literature review. The purpose of writing the title at this early stage is to help you clarify your aims and intentions. Examine your title after the paper has been written and make sure it accurately reflects the content of the paper. (See page 2.)  |

## Abstract

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|                     |  |
|---------------------|--|
| <b>Introduction</b> | The abstract is the reader's first encounter with your paper. Reviewers will form first impressions of your research by reading the abstract. Day (1994) states, "Usually, a good abstract is followed by a good paper; a poor abstract is a harbinger of woes to come."   |
| <b>Definition</b>   | The <b>abstract</b> is a: <ul style="list-style-type: none"><li>• brief summary of the principal findings of the paper.</li><li>• preview of the paper.</li><li>• stand-alone, self-contained document that can be read independent of the paper.</li></ul>  |
| <b>Contents</b>     | The abstract should <i>briefly</i> state: <ul style="list-style-type: none"><li>• the purpose of the research or the research problem (introduction),</li><li>• how the problem was studied (methods),</li><li>• the principal findings, including statistical analyses (results), and</li><li>• what the findings mean (discussion and conclusions).</li></ul> <p>While it is difficult to be both concise and descriptive at the same time, that is exactly what you should strive for when writing an abstract. Say only what is essential, using no more words than necessary to convey the meaning. Examine every word carefully.</p>   |
| <b>Rules</b>        | The abstract should be: <ul style="list-style-type: none"><li>• one or two paragraphs,</li><li>• no more than 175 words, and</li><li>• on the JSHS abstract form.</li></ul> <p>The abstract should:</p> <ul style="list-style-type: none"><li>• <b>not</b> include subheadings such as "Purpose" or "Results."</li><li>• <b>not</b> use first person, e.g., "I."</li><li>• <b>not</b> include information or conclusions that are <i>not</i> stated in the paper.</li><li>• <b>not</b> emphasize minor details.</li><li>• <b>not</b> contain bibliographic references, figures, or tables.</li><li>• <b>not</b> use jargon or abbreviations (<i>unless</i> they are commonly used and do not require explanation, e.g., DNA or UV light) .</li></ul> |
| <b>Sequence</b>     | Write the abstract after the paper is completed. Make sure it accurately reflects the paper's contents . (See page 2.)   |

## Acknowledgments

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|                     |  |
|---------------------|--|
| <b>Introduction</b> | As a matter of scholarly courtesy, you should acknowledge those who helped you technically, intellectually, and financially.   |
| <b>Definition</b>   | The <b>Acknowledgments</b> is a short paragraph where the researcher acknowledges the contributions of others to the research study.   |
| <b>Contents</b>     | The Acknowledgments should state: <ul style="list-style-type: none"><li>• where the research was conducted,</li><li>• when the research was done, and</li><li>• the names of those who provided major assistance with the study, including:<ul style="list-style-type: none"><li>✓ selection of topic,</li><li>✓ planning or guiding course of research,</li><li>✓ construction of apparatus,</li><li>✓ use of equipment or laboratory space, and</li><li>✓ other direct assistance.</li></ul></li></ul> |
| <b>Note</b>         | As a researcher, you are neither rewarded nor penalized by the judges for utilizing special advisors or equipment (Cousens, 1997). However, it is important that you properly acknowledge any assistance.  |

## Table of Contents

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|                     |  |
|---------------------|--|
| <b>Introduction</b> | A Table of Contents is <i>not</i> considered a part of a typical scientific research paper and is <i>not</i> a numbered page. However, JSBS guidelines require a Table of Contents.  |
| <b>Definition</b>   | A <b>Table of Contents</b> is an outline that indicates the location of the sections and subsections of the paper.   |
| <b>Purpose</b>      | The main purpose of a Table of Contents is to enable the reader to quickly find any section of the paper.  |
| <b>Rules</b>        | When making a Table of Contents: <ul style="list-style-type: none"><li>• list <i>only</i> the number of the first page of any section, e.g., "1," not "1-4."</li><li>• keep the right margin of the column of page numbers even by using a right-aligned tab.</li><li>• consider using leaders, a series of horizontal dots, to "lead" the eye across the page to the right number.</li><li>• <i>do not</i> use the word "page" with the number. It is self-explanatory.</li></ul> |

## List of Tables & List of Figures

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|                   |  |
|-------------------|--|
| <b>Definition</b> | A <b>List of Tables</b> and a <b>List of Figures</b> are outlines that indicate the location of any tables or figures in the paper.  |
| <b>Rules</b>      | When making a List of Tables, include: <ul style="list-style-type: none"><li>• table numbers,</li><li>• titles, and</li><li>• page numbers.</li></ul><br>When making a List of Figures, include: <ul style="list-style-type: none"><li>• figure numbers,</li><li>• captions, and</li><li>• page numbers.</li></ul> |
| <b>Comment</b>    | If the figure caption has more than one sentence, include <i>only</i> the first sentence in the List of Figures.   |

## Introduction

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|                   |   |
|-------------------|---|
| <b>Definition</b> | <p>The <b>Introduction</b> is:</p> <ul style="list-style-type: none"><li>• a clear statement of the problem or project and why you are studying it (Dodd, 1986).</li><li>• a map of the path you're going to take from problem to solution (Day, 1994).</li></ul> <p>It is <i>not</i> simply a literature and concept review.</p>   |
| <b>Contents</b>   | <p>The Introduction should contain:</p> <ul style="list-style-type: none"><li>• sufficient background information to allow the reader to understand and evaluate the results of your study (Day, 1994);</li><li>• a <i>brief</i> literature review. <i>Cite</i> and discuss previous research from <i>relevant</i> literature, and state how your research relates to or differs from others' work;</li><li>• the rationale for your study. Why did you choose that subject, and why is it important? and</li><li>• a simple statement of the most important point(s) that you will address in your paper.</li></ul>  |
| <b>Rules</b>      | <p>The Introduction should:</p> <ul style="list-style-type: none"><li>• proceed from the general to the specific. It should introduce the problem, present necessary background information, show the continuity between previous work and the work <i>you</i> did, and indicate <i>your</i> purpose and rationale.</li><li>• include only background information and studies that are <i>relevant</i> to the present study. <b>Do not</b> try to include <i>everything</i> that you know about the topic.</li><li>• cite the relevant literature sources in the text.</li><li>• assume that the reader is scientifically literate but <i>not</i> familiar with the specifics of the study.</li></ul> |
| <b>Sequence</b>   | <p>A literature review should be done <i>before</i> you conduct your research. However, you should <i>not finish</i> writing the Introduction until <i>after</i> the Discussion and Conclusions section (see page 2).</p>   |

## Materials and Methods

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| <b>Introduction</b> | <p>The cornerstone of the scientific method is reproducibility (Day, 1994). This section should describe the experimental design with sufficient detail for a trained researcher to replicate your experiments and obtain similar results.</p> <p>This section should also enable the reader to evaluate the appropriateness of your methods and the reliability and validity of your results (APA, 1994).</p>   |
| <b>Definition</b>   | <p>The <b>Materials and Methods</b> section describes:</p> <ul style="list-style-type: none"><li>• how you conducted your study,</li><li>• what materials and equipment you used, and</li><li>• what methods or procedures you followed.</li></ul> <p>It is <i>not</i> a numbered list of experimental steps or a cookbook recipe.</p>   |
| <b>Rules</b>        | <p>The Materials and Methods section should be written:</p> <ul style="list-style-type: none"><li>• in narrative, paragraph format.</li><li>• precisely—be specific. Don't leave the reader with unanswered questions.</li></ul> <p>The Materials and Methods section should <i>not</i> include any of the Results.</p>  |
| <b>Materials</b>    | <p>Materials are <i>not</i> listed separately, but rather included in the description of Methods. Include exact technical specifications for:</p> <ul style="list-style-type: none"><li>• chemicals: purity and names of suppliers. Use generic or chemical names, <i>not</i> trade names <i>unless</i> the known difference is critical.</li><li>• apparatus: type, brand, model. Describe your apparatus only if it is not standard and was constructed for your study. Use figures, if appropriate, to help the reader picture the equipment.</li><li>• techniques: standardization methods, solvent, concentrations, times, temperature.</li><li>• experimental animals, plants, and microorganisms: genus, species, special characteristics such as age and sex.</li></ul> <ul style="list-style-type: none"><li>✓ Use <i>metric</i> units for all quantities and temperatures.</li><li>✓ Include method of preparation.</li><li>✓ Include criteria for selection and an “informed consent” statement when human subjects are used.</li></ul> |

## Materials and Methods (cont.)

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| <b>Methods</b>  | <ul style="list-style-type: none"><li>• include precise description of the sample;</li><li>• include methods of data collection;</li><li>• provide all needed detail for <i>new, non-standard</i>, or <i>modification</i> of standard methods; and</li><li>• cite the literature reference and give only the details specific to your experiment when using a <i>standard</i> method.</li></ul>  |
| <b>Example</b>  | <p>Make sure you specify your methods precisely. As an example, suppose you collect water samples or collect organisms from lakes, wells, etc.</p> <ul style="list-style-type: none"><li>• What were the criteria for choosing the lakes/wells? the sampling locations in the lakes?</li><li>• Were the lakes/wells different in water quality or some other relevant characteristic?</li><li>• Did you include other "kinds" of lakes/wells?</li><li>• Were the procedures standardized (controlled)?</li><li>• Can you demonstrate that your sampling technique produced a random sample (i.e., that it wasn't biased)?</li><li>• What was your period of data collection? How many times did you sample? Dates?</li><li>• What were the weather conditions prior to sampling? Had it rained? Was the temperature notably different?</li><li>• Take a sample from several lakes/wells to see if you find the same occurrence in all.</li></ul> |
| <b>Sequence</b> | <p>It is a good practice to write the Materials and Methods section as you conduct your experiments so technical details are fresh in your mind. (See page 2.)</p>   |

## Results

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| <b>Introduction</b> | <p>The Results present the data, the most important part of the paper. The whole paper must stand or fall on the basis of the Results (Day, 1994).</p>   |
| <b>Definition</b>   | <p>The <b>Results</b> section contains all the major experimental findings of the study and their statistical analyses, presented in a logical order with text and visuals that complement and supplement the other.</p>   |
| <b>Contents</b>     | <p>The Results section contains:</p> <ul style="list-style-type: none"><li>• visuals (tables, figures, and/or illustrations) where necessary for clarity and conciseness,</li><li>• text that summarizes the data collected and points out highlights of visuals, and</li><li>• any appropriate statistical analyses of the data.</li></ul>  |
| <b>Visuals</b>      | <p>The visuals should:</p> <ul style="list-style-type: none"><li>• highlight an important point and be referred to somewhere in the text.</li><li>• be well designed so they are clearly understood <i>without</i> reference to the text.</li><li>• <b>not</b> be redundant. <b>Do not</b> present the <i>same</i> results in multiple visual formats, e.g., presenting the same results in both a table and a graph. Choose the best format for presentation. Are shapes and trends more important to the readers, or exact values?</li></ul> |
| <b>Text</b>         | <p>The text should:</p> <ul style="list-style-type: none"><li>• summarize the data collected, point out the important features, and connect the results with one another.</li><li>• <b>not interpret</b> the results and discuss the conclusions of the results (a trend can be mentioned, but no <i>interpretation</i> or extended <i>discussion</i> occurs in this section).</li><li>• <b>not</b> include raw data. This data should be in a table or in an appendix.</li></ul>  |
| <b>Sequence</b>     | <p>Prepare your tables or figures <i>before</i> writing the text. The visual representations will help you clarify your own thinking and make it easier for you to write the Results. This will also help reveal whether there are gaps in the data and whether more experimental work should be done.</p>   |

## Results (cont.)

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| <b>Tables</b> | Use tables to show large amounts of data (usually numbers) in a small space. If exact values must be listed, a table is normally preferred over a graph.  |
| <b>Rules</b>  | <ul style="list-style-type: none"><li>• Put table number and title above the table. The word "table" should be all caps (<i>TABLE 2. Chemical and...</i>). Tables should be numbered with Arabic numerals (in the order of appearance in text). Numbering will enable the writer to refer to them quite easily (<i>Table 2 shows that...</i>).</li><li>• Place columns to be compared next to each other, if possible.</li><li>• Label each column with a column heading. Make the headings clear but concise. Abbreviations may be used, but do not use periods. Capitalize first words in column headings.</li><li>• Include units of measure in the headings if appropriate, e.g., <i>Nitrates (mg/L)</i>.</li><li>• Use horizontal rules, or lines, if needed. Vertical rules are normally not used; columns are defined by spacing.</li><li>• Use single spacing for data and headings. In some instances, you may want to use wide space (extra line) to separate groups of data.</li><li>• Align numbers in each column on the right. However, if decimal points are used, the numbers should be aligned on the decimal point.</li><li>• Use an initial zero before the decimal (<i>0.25</i>).</li><li>• Use notes for more extensive explanation of data or headings. Notes are placed below the table and referenced by superscript letters.</li><li>• Order the notes to a table in the following sequence:<ul style="list-style-type: none"><li>• general notes provide information relating to the table as a whole; place the letter reference at the end of the title</li><li>• column (row) notes refer to a particular column (row); place the letter reference at the end of column (row) heading</li><li>• probability level notes indicate the results of tests of significance</li></ul></li><li>• Tables should be placed as near as possible to the discussion in the text.</li></ul> |

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| <b>Figures</b>     | Figures are used to convey the overall pattern of the results at a quick glance. The most common figures are graphs, photographs, and diagrams.   |
| <b>Rules</b>       | <ul style="list-style-type: none"><li>• Make all figures in black and white for reproduction purposes. If color is integral to the research, a request for an exception should be made to the Symposium Director, and <i>12 copies of each figure must be provided</i> for the paper reviewers .</li><li>• Number all figures with Arabic numerals in order of discussion in the text. Number figures separately from tables.</li><li>• Label both axes on graphs with the variable being measured, the units of measurement, and the scale.</li><li>• Place the figure caption and legend below the figure. A caption is a brief but descriptive title. For example, <i>FIGURE 2. Average Nitrate Content of Wells</i>. A legend consists of one or more sentences that describe what is shown in the figure and point out important features. Sometimes a caption and legend are combined. For example, <i>FIGURE 2. Average Nitrate Content of Wells. The average of all seven readings of the nitrate level for each well is given. The dotted line represents the maximum contaminant level (MCL) which the EPA has established for public drinking water.</i></li><li>• Figures should be placed as near as possible to the discussion in the text.</li></ul> |
| <b>Bar Graphs</b>  | Bar graphs are appropriate for showing discrete values and comparisons. They emphasize individual amounts rather than trends or direction. They have the most impact when used to display relatively few values of one or more series (Woolston, 1988).   |
| <b>Line Graphs</b> | Line graphs are used to show trends and relationships. They allow plotting values of a quantity as a function of another variable. The horizontal axis most often depicts time (Woolston, 1988).  |
| <b>Pie Graphs</b>  | Pie graphs are 100-percent graphs and are used to show percentage distribution of parts of the whole. They are intended to provide an overview rather than exact values (Woolston, 1988).   |

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## Discussion and Conclusions

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|---------------------|---|
| <b>Introduction</b> | The Discussion and Conclusions can be the hardest section to write because you <i>interpret</i> your results in this section and draw conclusions.  |
| <b>Definition</b>   | A <b>Discussion and Conclusions</b> section is an <i>analysis</i> of your results. It is a concise discussion of your most important results in the context of other peoples' work (as reported in the Introduction) and the conclusions drawn based upon your research findings (as reported in the Results).  |
| <b>Contents</b>     | It should: <ul style="list-style-type: none"><li>• briefly restate your hypotheses; explain how your data either supported or rejected your initial research question(s);</li><li>• show how your results agree (or contrast) with previously published work (include appropriate literature citations);</li><li>• state your conclusions as clearly as possible; (Remember: not all papers have earth-shattering conclusions.)</li><li>• summarize your evidence for each conclusion;</li><li>• acknowledge any limitations which affect the results; discuss any other factors over which you had no control; explain their possible effect on study outcomes;</li><li>• include suggestions for procedural improvements, if applicable;</li><li>• discuss any theoretical implications or practical applications of your work; and</li><li>• make recommendations for future research.</li></ul> |
| <b>Rules</b>        | The Discussions and Conclusions should: <ul style="list-style-type: none"><li>• proceed from most specific (your results), through the more general (others' results), to the most general (implications drawn from your study)</li><li>• <b>not</b> simply <i>restate</i> the results. This section should <i>analyze</i> the results.</li></ul>   |

## References

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|                       |  |
|-----------------------|--|
| <b>Introduction</b>   | Virtually all scientific papers rely to some degree on previously published work. When a fact or an idea is borrowed (whether directly or paraphrased) from another source, it must be acknowledged, or cited, in the text and the origin of the information must be revealed.   |
| <b>Definition</b>     | A <u>citation</u> is the formal acknowledgment within the text. The citation serves as a link between the text in which it appears and the formal, alphabetical list at the end of the paper called <u>References</u> (Ebel, 1987).  |
| <b>Citing in Text</b> | Although there are several systems for citing in text, the IJSHS follows the author-date system. The citation (author and date) should be placed naturally into the flow of the sentence.<br><br><i>Pascal and co-workers (1981) first isolated a mutant of <u>E. coli</u> K-12 which could no longer ferment glucose.</i><br><br><i>Examination of codon usage predicts ADH to be a highly expressed protein in <u>E. coli</u> (Ikemura, 1985).</i><br><br>If the name of the author appears as part of the text, as in the first example, cite only the year of publication in parentheses. Otherwise, place both the name and year, separated by a comma, in parentheses as in the second example.<br><br>When there are two authors, cite them both ( <i>Smith and Kaplan, 1980</i> ), but in the case of three or more authors, cite only the name of the first author and indicate the rest by using "et al." ( <i>Lurz et al., 1979</i> ), which is Latin for <i>and others</i> . |
| <b>Rule</b>           | All <i>citations in text</i> must appear in the <i>References</i> ; and all references in the <i>list</i> must be cited in the <i>text</i> . A References list differs from a Bibliography, in which you list everything you have read, whether it is cited or not.  |
| <b>Punctuation</b>    | For end-of-sentence citations, the period for the sentence is placed <i>after</i> the citation, <i>not</i> before it.<br><br><i>The diencephalic structure which controls classification responds better to positive <b>reinforcement</b> (Knowlton and Squire, 1993).</i><br><br>NOT... <i>reinforcement. (Knowlton and Squire, 1993)</i>   |

## References (cont.)

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### Formatting the List

- left justified margin with additional lines indented five spaces (1/2")
  - single spaced; double space *between* references
  - arranged alphabetically by first author's last name
  - Periods separate major components.
  - Colons separate titles from subtitles, cities from publishers, and volumes from pages.
- 

### Authors

- A single-author entry comes before a multi-author entry if they begin with the same name.
  - Works by the same person are arranged chronologically by date of publication.
  - When a work has more than one author, their names are listed in the order in which they appear on the title page.
  - When a book or pamphlet has no individual author's name, or group of authors' names, and is published by an agency, association, or named group: the name of the group may serve as the author's name in citations in text and in the References list. The name of the group is spelled out in the first citation and abbreviated thereafter.
  - Major reference works, such as encyclopedias, with a large editorial board: list the name of the lead editor or directing editor if no author is cited.
  - Name of the author or editor is unknown: list alphabetically by the first important word in the title.
- 

### Contents

- For *journals*, include author, year of publication, title of article, abbreviated journal name, volume number (if every issue begins with page 1), and page numbers.
  - For *books*, include author (or editor), year published, book title, location of publisher, and name of publisher.
  - For *sources other than a book or journal*, include enough information so that the source can be identified and located.
- 

### Titles

- Article and book titles are capitalized in sentence style.
  - Journal titles are capitalized in heading style.
  - Book and journal titles are italicized.
  - Article titles are **not** italicized or enclosed in quotations.
- 

### Misc.

- Locations that are well known can be listed without a state abbreviation, e.g., New York, Boston, Chicago.
- 

### Book:

- one author Day, R.A. 1994. *How to write and publish a scientific paper*. 4th ed. Phoenix: Oryx Press.
  - more than one author Woolston, D.C., P.A. Robinson, and G. Kutzbach. 1988. *Effective writing strategies for engineers and scientists*. Chelsea, MI: Lewis Publ.
- 

### Dictionary, editor

- Urdag, L., ed. 1972. Magnet. In *The Random House college dictionary*. New York: Random House.
- 

### Encyclopedia:

- with author Hart, L.W. 1988. Magnet and magnetism. In *World Book*. Vol. 13. Chicago: World Book.
  - editor/ no author Lorimer, L.T., ed. 1993. Magnet and magnetism. In *Encyclopedia Americana*. Vol. 15. New York: Americana Corp.
- 

### Internet

- Martin, Linda. 08 Nov 1997. General Information. <<http://www.science.siu.edu/ijshs/info.html>> Accessed 20 Nov 1997.
- 

### Interview

- Barber, J.D. 8 May 1995. Interview by author. Carbondale, IL.
- 

### Journal Article:

- one author Clark, D.P. 1989. The fermentation pathways of *Escherichia coli*. *FEMS Microbiol. Rev.* 63:223-234.
  - more than one; title & subtitle Kohara, Y., K. Akiyama, and K. Isono. 1987. The physical map of the whole *E. coli* chromosome: application of a new strategy for rapid analysis and sorting of a large genomic library. *Cell* 50:495-508.
- 

### Magazine, paginated by issue

- Cowley, G. 23 Jan 1995. HIV's raw aggression. *Newsweek*. 75(4):58.
- 

### Newspaper:

- no author Study finds free care used more. May 1989. *APA Monitor*. 14.
  - discontinuous pages McDonald, K.A. 15 Dec 1995. Researchers ponder a stormy forecast. *The Chronicle of Higher Education*. A12, A16.
- 

### Pamphlet, organization as author

- American Society for Microbiology. 1994. Slide and poster requirements. Pamphlet. Washington, DC: ASM.
- 

### Telephone conversation

- Barber, J.D. 8 May 1995. Personal communication
-

## Appendices (optional)

---

**Introduction** Appendices contain supplemental information such as lists of terms, definitions, and questionnaires that are useful but not essential to the body of the research paper. Most readers will not bother to check appendices.

---

**Rules** Appendices should be included *only* if they help readers to understand, evaluate, or replicate the study (APA, 1994). For example, you have a large table of raw data, but most of it is *not* essential to the discussion in the paper. You could include the complete table as an appendix and a smaller table with a subset of data in the text.

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## Writing, Revising, and Proofreading

---

**First Draft** Have a clear purpose in mind when you begin writing, but don't try to think of everything at once. Papers are rarely written correctly on the first draft. This means you must be sure to allow yourself enough time for writing *and revising*.

---

**Review** After the first draft is written, set it aside for at least a day or so, then re-read it to yourself. Also, allow enough time in the process to give the draft to your science and English teachers, as well as someone who is not familiar with your research project, for comments. Ask them to mark any section that was confusing or they had to read twice to understand.

---

**Revise** When you revise, aim for improving clarity.

- Use third person in grammar, when possible.
- Examine the verb tenses throughout your paper.
  - ✓ Most or all of the Abstract should be written in past tense.
  - ✓ Present and past tenses are correct in the Introduction.
  - ✓ Past tense or present perfect tense (*researchers have shown*) is appropriate for the literature review and the description of the Materials and Methods.
  - ✓ Use past tense to describe Results .
  - ✓ Use the present tense for the Discussion and Conclusions. The present tense allows your readers to join you in your consideration of the matter at hand.
- Examine your use of pronouns, especially "it." Is the meaning clear?
- Examine your sentences for needless words.

---

**Proofread** Proofread for correct spelling and sentence structure! Computer spell-checkers do not recognize misspelled words if they are valid words, nor do they check the grammar.

Any errors in spelling, grammar, sentence structure, punctuation, or misuse of a word is distracting and affects the reader's confidence in you.

A paper with writing and typing errors may score poorly even if the research itself is excellent.

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## Typing Specifications

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### Rules

- All papers must be typed, using standard 12-point, serif typeface (such as Times), and double-spaced.
  - Papers must be printed single-sided on 8 1/2 x 11 inch paper with one-inch margins (on all sides).
  - Output from dot matrix printers is not acceptable.
  - The typical research paper should be between 5 and 12 pages. It may not exceed 20 pages. Lengthy papers are neither necessary nor desired.
  - The title page shows the title of the paper, the author's name, school name, and date of submission.
  - All pages except the title page, abstract, acknowledgments, and table of contents must be numbered. Type the numbers, using Arabic numerals, within the one-inch margin on the *bottom* of the page. These numerals should be centered and one-half inch from the bottom edge of the paper.
  - Do *not* include your name on each page of the paper. The papers are "blind" reviewed, which means that all identifying information such as name and school must be removed prior to paper review.
  - Each section of the paper should be identified by a heading, centered within the page margins, and typed using the same typeface and font size as text. All letters are capitalized.
  - Use abbreviations sparingly, but if a very long name or term is repeated throughout the paper, an abbreviation is acceptable.
  - Abbreviations should be defined the first time they appear in text by placing the abbreviation in parentheses following the spelled-out word. For example, *No molecule with a single 4-member ring was isolated until tetramesityl cyclodisiloxane (TMCDS) obtained by oxidation of disilene. TMCDS was ...*
- 

## The Oral Presentation

---

### Timing

The presentation may not exceed 15 minutes and is followed by a five (5) minute question-and-answer period.

- A session moderator will aid the student speaker in maintaining the time and in fielding questions from the audience.
  - The timing procedure includes a 12-minute warning signal from the moderator, and a 15-minute stop time. At the 15-minute point, the presentation will be stopped, even if the student speaker has not finished.
- 

### Answering Questions

Following the presentation, the session moderator will ask for questions from the judges, followed by questions from the audience.

- The speaker *must* repeat or paraphrase each question before answering it so the audience understands the entire dialogue.
  - Questions intended to harass the student speakers will not be allowed by the session moderator.
- 

### Suggestions

Explain your research in enough detail so the audience understands what you did, how you did it, and what you learned. Be sure your presentation is logical and easy to follow. Make your message clear.

- Avoid jargon or terminology the audience might not understand. If it is essential to use specialized terms, remember to explain them *briefly*. Be prepared to define terminology used, if necessary.
  - Graphs, tables and other illustrations may help explain your results. Remember to name the variables on each axis of a graph, and state the significance of the position and shape of the graph. Do not, however, read each number in the table/figure. Call attention instead to important points.
  - Deliver your presentation at a comfortable pace. Time yourself. Classroom practice sessions provide an excellent "live" audience and help build confidence. Videotape the presentation, if possible. Listen and watch for "ah's," "er's," or nervous mannerisms.
  - Plan to speak for 12 minutes; that "builds in" time to finish within the allotted 15 minutes.
-

## The Oral Presentation (cont.)

---

- Acknowledgments are presented at the *end* of an oral presentation.
- No written handouts are permitted.
- Research apparatus may be demonstrated only if it is integral to the presentation and only if the apparatus is hand-held.

### Visuals

---

#### *General Guidelines*

- Available audio-visual equipment includes 35 mm slide projector with remote control, overhead projector, laser pointer, and videocassette player (if requested; see restrictions below on using VCR's.)
- Visuals (overhead transparencies or slides) should be laser printed or professionally done.
- Number your visuals in sequence so they can be easily identified. Many times, visuals need to be reshown during questions.
- The first visual should be equivalent to the title page of the paper.
- Visuals should be brief, simple, and uncluttered. Focus on important information. Each visual should make one simple statement and supplement what you are saying while the visual is on the screen.
- Use good judgment in determining the number of visuals and balance their contents. Although you do not want to quickly flash multiple visuals, you should not spend too much time on a single visual either. Typically, a 15-minute presentation will have 5-6 visuals (Ebel, 1987).

---

#### *Overhead Transparencies*

- Be sure that your transparencies are legible from a distance. Titles: at least 18 points and sans serif typeface, e.g., Helvetica. Blocks of text: 16 points (14 points minimum) and serif typeface, such as Times. Recommended line spacing is 1.5 lines.
  - Although the stage area of the overhead projector generally measures about 10 by 10 inches, restrict your visual to a rectangular "message area" of about 7 1/2 by 9 1/2 inches.
- 

---

#### *Overhead Transparencies (cont.)*

- Horizontal orientation generally works better. On a square screen, the audience has difficulty seeing the bottom fourth of a vertical format transparency.
  - Bulleted items should be no more than 2-3 lines per bullet with extra white space (1/2 to 1 line) between items.
  - Commercially-available frames make a transparency easy to handle, and key words can be written on the frame.
- 

#### *Slides*

- Use 2 x 2-inch (35 mm) slides.
  - When preparing text for slides, use no more than 9 double spaced lines per slide. Each line should be at most 4.5 inches wide (about 50 characters in non-proportional font).
  - If you can read the slides without a magnifier, people in the audience can probably read them on the screen. It is better to have the letters too large than too small.
  - Thumb spot all slides in the lower left corner when the slide reads correctly on hand viewing. Add sequence numbers.
  - Have slides in carousel tray with thumb spot visible in upper right hand corner.
- 

#### *Color Choices*

- Color is not required. Color should be used only to clarify or make the visual more legible.
  - Overhead transparencies most commonly have black letters on white (clear), but slides are frequently made using other colors.
  - Most legible are black letters on yellow. The following are listed in descending order of legibility: green, red, or blue on white (clear); white (clear) on blue; black on white (clear); and yellow on black (Heinich et al., 1993).
  - Do not overuse color. Use good judgment.
-

## VCR/Computer Restrictions

---

|                     |  |
|---------------------|--|
| <b>Introduction</b> | Students using VCR's and computers during their presentation must abide by the following rules. Improper use will not only distract the audience but also could affect evaluation by the judges.   |
| <b>Rules</b>        | <ul style="list-style-type: none"><li>• If using computers or video, notify the Symposium Director at least two weeks in advance of the meeting to discuss and review specific technical details (e.g., projection, set-up, etc.) and to allow for availability of video equipment. Students must provide their own computer equipment and software.</li><li>• The use of software such as PowerPoint may be used to prepare or to drive slides or overheads.</li><li>• Only VHS, 1/2" tape, format is permitted.</li><li>• The video component cannot make up more than two (2) minutes of the presentation.</li><li>• No audio or background music is permitted other than sounds that are an integral part of the research. Recorded or mechanically produced narration is not permitted. Narration must be done in person by the speaker.</li><li>• Computer generated graphics, video (and audio, if any) may be used only for those aspects of the presentation that cannot be adequately presented by slides or overheads.</li><li>• Computer-based material must be an integral part of the research and should not be used for presentation of common procedures, illustrating equipment or showing laboratory facilities.</li><li>• Videos and computers should illustrate work that was done and should not be used for stimulation or aesthetic value.</li></ul> |

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## Judging Criteria

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### *The Student's Involvement with Science:*

|  |  |
|--|--|
| <b>Problem &amp; Hypothesis</b>                    | <ul style="list-style-type: none"><li>• originality in identification of problem and hypothesis</li><li>• clarity in stating problem</li><li>• objectives and reasons for performing the research</li></ul>  |
| <b>Background Information &amp; Prior Research</b> | <ul style="list-style-type: none"><li>• acknowledgment of sources</li></ul>  |
| <b>Design of Investigation</b>                     | <ul style="list-style-type: none"><li>• extent of student's involvement in designing the procedures</li></ul>  |
| <b>Investigative Procedures</b>                    | <ul style="list-style-type: none"><li>• identification of important variables; control of variables</li><li>• laboratory skills and techniques</li><li>• selection of proper equipment for research task</li><li>• quantity and quality of data generated by investigative procedures: observations/measurements/data gathering/statistical analysis</li><li>• recognition of the limitations in the accuracy and significance of the results obtained</li><li>• interpretation of data; conclusions supported by data</li><li>• problem solving</li></ul> |
| <b>Overall</b>                                     | <ul style="list-style-type: none"><li>• creativity/originality</li><li>• evidence of student's understanding of the scientific or technological principles employed in investigation</li><li>• applications, next steps, or future research</li></ul>  |

---

## Judging Criteria (cont.)

---

### *The Student's Effort and Performance:*

|                             |   |
|-----------------------------|---|
| <b>Overall</b>              | <ul style="list-style-type: none"><li>• duration of project and amount of work involved</li><li>• acknowledgment of major assistance</li><li>• evidence of student's understanding</li></ul>  |
| <b>Written Presentation</b> | <ul style="list-style-type: none"><li>• organization of the paper</li><li>• composition (spelling, grammar, clarity of thought)</li><li>• abstract (content, format, grammar, organization)</li></ul>   |
| <b>Oral Presentation</b>    | <ul style="list-style-type: none"><li>• clarity in stating problem and hypothesis</li><li>• clarity in describing design, procedures, problems, and how they were handled</li><li>• clarity in presenting data, interpretations, and conclusions</li><li>• overall organization</li><li>• definition of terms as necessary</li><li>• appropriate use of visual aids</li><li>• clarity of enunciation and voice projection</li><li>• response to questions</li></ul> |
| <b>Note</b>                 | <p>The presentation is important in the evaluation; however, content, not form, will be given the major weight.</p>   |

## The Poster

---

|                       |   |
|-----------------------|---|
| <b>Definition</b>     | The poster is a hybrid between the research paper and the oral presentation.  |
| <b>Comment</b>        | Most of the comments from the preceding pages also apply to posters. However, this section will emphasize the differences and unique aspects of poster presentations.   |
| <b>Poster Session</b> | The JSBS Poster Session will be organized similar to those at scientific and professional meetings. The poster session will be scheduled as a regular part of the Symposium with no other activities occurring at the same time.  |
| <b>Submission</b>     | <p>To participate in the Poster Session, you must submit the following:</p> <ul style="list-style-type: none"><li>• Up to a five (5) page typed paper describing the original research project and main findings. The paper should have the same sections as the poster, i.e., Introduction, Methods, Results, Conclusions, Acknowledgments.</li><li>• An abstract on the JSBS Abstract Form</li><li>• A Biographical Sketch form</li><li>• A student photo</li></ul> |
| <b>Comment</b>        | The biographical sketch and photo are included, along with the student's abstract, in the program booklet that is distributed to all Symposium participants.  |
| <b>Composition</b>    | <p>The poster contains the following sections:</p> <ul style="list-style-type: none"><li>• Title</li><li>• Student's name and school</li><li>• Abstract</li><li>• Introduction</li><li>• Methods</li><li>• Results</li><li>• Conclusions</li><li>• Acknowledgments</li></ul>  |

## The Poster (cont.)

---

- Differences** The most important differences are:
- A poster is more concise since the author is present to explain and elaborate. You should typically have a single page for each section.
  - There is more emphasis on graphics.
  - You can use photographs in addition to other illustrations.
  - Figures may be in color.

---

**Display** A display wall (approximately 1 meter wide by 2 meters high) will be provided for each participant.

- All display materials must be attached to the wall. Table space will **not** be available.
- It is best to have materials pre-mounted on large-size (color) mounting boards.
- Posters should be readable from a distance of 4 feet.
- The title should be at least one inch (72 pts.) in height. The student's name and school should be 3/4 inch high (54 pts.). All other lettering should be in 24-point font size.
- Use sans serif typeface (such as Helvetica) for poster title, student's name and school, and major headings.
- Blocks of text should be serif typeface (such as Times).
- The poster should be balanced and organized in a logical, sequential order.
- Determine in advance what you will display and how it will be organized.
- Keep the amount of text to a minimum. Emphasize graphics—tables, charts, graphs, and photos.
- Use white space to make the reading easier.

---

**Presentation** In the poster session, poster presenters remain close to their posters and are available to answer questions and discuss their research.

- Each poster presenter will be given three (3) minutes to highlight the significance of the research to a panel of judges. Questions by the judges will follow.
  - Other participants of the Symposium will be viewing the displays during judging.
- 

## Poster Judging Criteria

---

- Research Design**
- Clarity in stating the problem
  - Identification of important variables
  - Appropriateness of research equipment
  - Recognition of limitations in the data
  - Degree to which the data supported the conclusions
  - Originality of the research topic

- 
- Poster**
- Effective use of tables and/or figures in presenting data
  - Accuracy of spelling and grammar
  - Neatness and organization of poster

- 
- Presentation**
- Organization of presentation
  - Handling of questions from judges
-

## Non-Human Vertebrates

---

### Rules

The Junior Science and Humanities Symposium has adopted the following rules on non-human vertebrate experimentation (adapted from Bonkalski et al., 1994).

- Only animals that are lawfully acquired shall be used in experimentation and their retention and use shall be in every case in strict compliance with state and local laws and regulations.
  - Animals used in experimentation must receive every consideration for their bodily comfort; they must be kindly treated, properly fed, and their surroundings kept in a sanitary condition.
  - No intrusive techniques may be used, including surgery, injections, or taking of blood.
  - When animals are used by students for their education or the advancement of science, such work shall be under the direct supervision of an experienced teacher or an investigator at a research institution with an approved active protocol for the use of vertebrate animals for this research.
- 

## Human Subjects

---

### Rules

The Junior Science and Humanities Symposium has adopted the following rules on research involving human subjects (adapted from Bonkalski et al., 1994).

- No project may use drugs, food, or beverages in order to measure their effect on a person.
  - Projects that involve exercise and its effect on pulse, respiration rate, blood pressure, and so on are approved if a valid normal physical examination is on file and provided the exercise is not carried to the extreme.
  - If your research involves administration of questionnaires or surveys, a proper consent from subjects must be obtained.
  - If you are conducting research that involves human subjects and your school has no formal policy regarding such research, contact the JSHS Director for guidelines.
  - No cultures involving human cultures of any type—mouth, throat, skin, or otherwise—will be allowed.
  - Tissue cultures purchased from reputable biological supply houses or research facilities are suitable.
  - The only human blood that may be used is that which is either purchased or obtained from a blood bank, hospital, or laboratory. No blood may be drawn by any person or from any person specifically for a science project. This rule does not preclude a student making use of data collected from blood tests not made exclusively for a science project. Blood may not be drawn exclusively for a science project.
- 

## Sample Pages

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### Pages 31-34

These pages show selected sections of a former research paper (reprinted with permission).

---

ACKNOWLEDGMENTS

This research was conducted during the months May–December 1998. Research laboratory space, equipment, supplies, and assistance were provided by Dr. Jim Eilers, Dr.

Virginia Bryan, Dr. Dennis Kitz, Ms. Illinois University Edwardsville (SI) regarding statistical analysis. Mr. B microscope. Dr. Beverly Friend dev complete this project. Well owners

**Abstract Form** 20th Annual Illinois Junior Science and Humanities Symposium  
Southern Illinois University Carbondale • March 22–24, 1998

Chemical and Microbiological Quality of Private Well Water  
Valerie Wappelhorst, 305 Catalpa, Roselle, IL 60172  
Lake Park High School, Roselle, IL  
Mentor: Dr. Beverly Friend

The chemical and microbiological quality of water from six private wells in Madison and St. Clair counties was evaluated. Samples were collected over an eight-month period and were analyzed for nitrate, pH, total solids, heterotrophic plate count, coliforms, *Escherichia coli* (*E. coli*), and fecal streptococci. Microbial isolates were selected and characterized using selective and differential media, biochemical tests, and microscopy.

The nitrate nitrogen values varied from 0 to 21.2 mg/L with one well exceeding the Maximum Contaminant Level (MCL) of 10 mg/L for drinking water. Nitrates were significantly different for wells ( $p < 0.001$ ) but not for dates. The pH and solids levels differed significantly for both wells and dates. The heterotrophic counts ranged from 1,200 to  $>5.7 \times 10^6$  colony forming units (CFU)/100 ml, and were significantly different for wells ( $p < 0.05$ ) but not dates. All samples exceeded the recommendation of 100 CFU/100 ml. Coliforms ranged from 0 to 6,600 CFU/100 ml and were significantly different for wells ( $p < 0.01$ ) and dates ( $p < 0.01$ ). Over 90% of the samples exceeded the MCL of zero coliforms. *E. coli* was found in three of the wells. The presence of high nitrates and extensive microbial contamination in these wells indicates that well owners should routinely sample and treat their wells.

Chemical and Microbiological Quality of Private Well Water

Valerie Wappelhorst  
Lake Park High School

January 16, 1998

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upper and lower case.  
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INTRODUCTION

The National Primary Drinking Water Regulations of the United States Environmental Protection Agency (EPA) apply to all public potable water systems in the United States. There are primary regulations establishing a maximum contaminant level (MCL) for microbiological, inorganic, organic, and radiological contaminants and secondary regulations (non-enforceable guidelines) for taste, odor, and aesthetics. There are no primary standards for either pH or total dissolved solids in public drinking water. The secondary standard for pH is 6.5 to 8.5 and for solids is 500 mg/L (35 Illinois Administrative Code).

U.S. obtain drinking water from  
s 400,000 private wells supplying  
ral areas (Korab, 1993). Since water  
typically do not test their wells as  
ply wells.  
y/L nitrate nitrogen for public

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TABLE 2  
Chemical and Microbiological Content of Well Waters

| Sample            | Dates                | pH               | TDS <sup>a</sup><br>mg/L | Nitrate N <sup>b</sup><br>mg/L | HPC <sup>b</sup><br>CFU/100ml | Coliform<br>CFU/100ml | <i>E. coli</i><br>CFU/100ml | Fecal Strep<br>MPN/100ml |
|-------------------|----------------------|------------------|--------------------------|--------------------------------|-------------------------------|-----------------------|-----------------------------|--------------------------|
| MCL               | 6.5-8.6 <sup>c</sup> | 500 <sup>c</sup> | 10 <sup>c</sup>          | 200 <sup>c</sup>               | 0                             | 0                     | 0                           | 0                        |
| Well 1<br>Madison | 5/09                 | 8.0              | 90                       | 9.3                            | 20600                         | 1200                  | 0                           |                          |
|                   | 6/13                 | 7.2              | 59                       | 8.2                            | 9100                          | 400                   | 0                           |                          |
|                   | 7/11                 | 7.2              | 50                       | 7.1                            | 1400                          | 100                   | 0                           |                          |
|                   | 8/08                 | 7.0              | 30                       | 7.9                            | 3200                          | 600                   | 0                           |                          |
|                   | 9/12                 | 7.1              | 69                       | 8.0                            | 14000                         | 0                     | 0                           | 170                      |
|                   | 11/14                | 6.5              | 50                       | 5.6                            | 9300                          | 200                   | 0                           | 30                       |
|                   | 12/12                | 6.2              | 40                       | 7.8                            | 8800                          | 100                   | 0                           |                          |
| Well 4            | 11/10                | 7.2              | 700                      | 11100                          | 1200                          | 700                   | 0                           |                          |
|                   | 8/30                 | 7.2              | 500                      | 83000                          | 1000                          | 500                   | 0                           |                          |
|                   | 2/80                 | 7.2              | 600                      | 2800                           | 800                           | 600                   | 0                           |                          |
|                   | 10/50                | 7.2              | 1200                     | 10500                          | 2800                          | 1200                  | 0                           |                          |
|                   | 3/90                 | 7.2              | 0                        | 3900                           | 0                             | 0                     | 60                          |                          |
|                   | 1/64                 | 7.2              | 0                        | 16400                          | 300                           | 0                     | 70                          |                          |
|                   | 10/00                | 7.2              | 0                        | 10000                          | 200                           | 0                     |                             |                          |
|                   | 9/40                 | 7.2              | 0                        | 9400                           | 400                           | 0                     |                             |                          |
|                   | 9/60                 | 7.2              | 0                        | 9600                           | 600                           | 0                     |                             |                          |
|                   | 12/00                | 7.2              | 0                        | 1200                           | 1000                          | 800                   |                             |                          |
| 2/20              | 7.2                  | 0                | 2200                     | 100                            | 0                             |                       |                             |                          |
| 3/37              | 7.2                  | 0                | 33700                    | 0                              | 0                             |                       | 90                          |                          |
| 2/00              | 7.2                  | 0                | 2000                     | 200                            | 0                             |                       | 200                         |                          |
| 3/05              | 7.2                  | 0                | 3050                     | 0                              | 0                             |                       |                             |                          |
| 12/30             | 7.2                  | 0                | 12300                    | 1600                           | 0                             |                       |                             |                          |
| 3/50              | 7.2                  | 0                | 3500                     | 600                            | 0                             |                       |                             |                          |
| 1/56              | 7.2                  | 0                | 15600                    | 600                            | 0                             |                       |                             |                          |
| 5/10              | 7.2                  | 0                | 51000                    | 4400                           | 0                             |                       |                             |                          |
| 3/00              | 7.2                  | 0                | 30000                    | 700                            | 0                             |                       | 110                         |                          |
| 2/25              | 7.2                  | 0                | 28250                    | 1500                           | 0                             |                       | 90                          |                          |
| 1/73              | 7.2                  | 0                | 17300                    | 600                            | 0                             |                       |                             |                          |

**RESULTS**

As shown in Table 2, the pH levels ranged from 5.6 to 8.3 and were significantly different for both wells (p<0.001) and dates (p<0.001) as determined by two factor ANOVA using ranked data. Solids ranged from 10 to 140 mg/L and also were significantly different for wells (p<0.001) and dates (p<0.01). The nitrate nitrogen in the wells varied from 0 to 21.1 mg/L. These values were significantly different for wells (p<0.001) but not for dates. The nitrate levels for well 1 (7.7 ± 1.2 mg/L) and well 4 (7.4 ± 0.8 mg/L)

were slightly less than the MCL (10mg/L) and the mg/L exceeded the MCL by almost two-fold (Fig

The heterotrophic counts ranged from 1,2 mL and were significantly different for wells (p<0 values are higher than the recommended level of 2 drinking water. The coliforms ranged from 0 to 6, significantly different for wells (p<0.01) and dates 42) of the samples exceeded the MCL of zero coli was found in four of the seven samples from well 2 from wells 3 and 6. Fecal streptococci (30 to >2.4 present in all wells. The average microbial center Figure 4.

A total of 23 isolates were identified on the morphological and biochemical characteristics (A

**MATERIALS AND METHODS**

**Sampling Sites and Protocols**

Wells 1-3 were located in Madison County, Illinois, and wells 4-6 were located in St. Clair County, Illinois. Well location, construction, age, and depth are shown in Table 1. None of the wells had been chlorinated. Seven samples from each well were collected in sterile containers and held at 10 °C for no more than 24 hr prior to microbial analysis.

**Chemical Analyses**

The pH of each sample was determined with an Orion pH meter which was standardized prior to use (American Public Health Association [APHA], 1989). The total dissolved solids were determined in a drying oven using the Total Solids Dried at 103-105 °C Method (APHA, 1989).

Nitrate nitrogen was determined using the NitraVer 5 cadmium reduction method (Hach Company, 1992). All glassware was prewashed in 0.1 N HCl and rinsed in deionized water prior to use. Potassium nitrate standards were prepared at concentrations of 1, 5, 10, and 20 mg/L nitrate. Duplicate 5.0 g portions of each standard and two 5.0 g portions of deionized water (blank) were placed in test tubes. One packet of NitraVer 5 was added to each tube and the tube shaken vigorously for 1 min. The absorbance at 385 nm was determined in a Spec 20 which had been previously zeroed against the blank. Water samples were treated and analyzed the same way as the standard solutions.

**Microbiological Analyses**

The heterotrophic plate count was determined with Redigel Aerobic Count plates (3M Microbiology Products, 1995). Both 1.0 and 0.1 ml aliquots were plated in duplicate and incubated at 35 ± 0.5 °C for 24 hrs and counted using standard methods. Coliforms

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**DISCUSSION AND CONCLUSIONS**

The purpose of this project was to evaluate the chemical and microbiological quality of private well water and test the hypothesis that quality varies between wells and sampling dates. The pH, total solids and coliforms were significantly different for both wells and dates, while nitrates and heterotrophs were significantly different for wells only. The nitrate data are consistent with those of Panno et al. (1966) who reported that nitrate levels differed significantly for wells but not for periods. The variability

Although the total dissolved solids, were close to the MCL of 10 mg/L (Table 1, Panno et al., 1966). Water contained for human adults and months of age (Bicki 1992; Ward et al., 1992). The nitrate level mg/L found during the

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of nitrate and nitrite in drinking

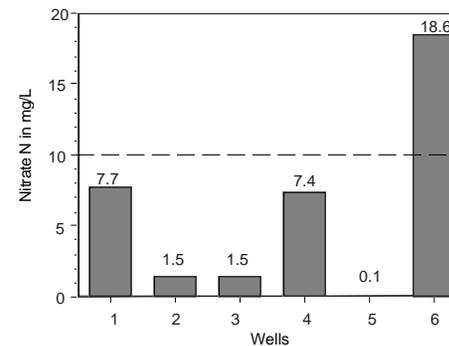


FIG. 2. Average Nitrate Content of Wells. The average of all seven readings of the nitrate level for each well is given. The dotted line represents the maximum contaminant level (MCL) which the EPA has established for public drinking water.

**EDITORIAL NOTE: This figure has been enlarged for ease of reading. It would not be scaled as such in an actual paper.**

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