Guide to Writing a Scientific Article

The Purpose of a Scientific Article

The purpose of this guide is to provide you with guidelines, and suggestions for structuring and writing a scientific article. This guide describes the purpose, content and writing style for each of the sections of a typical scientific article. Additionally, examples of well-written parts of each section of a sample article are provided. Read this entire guide before you begin writing the first draft of your research article.

Consider your audience - The first rule of writing is to consider who your audience. You must be aware of who it is that could potentially read your article. As you think about this, consider their level of expertise, and interest in the topic area. This will help you to write in a way that best communicates your findings and ideas to you intended audience. Depending on their level of expertise you may have to make assumptions about basic background knowledge they may possess, perhaps educate them about your topic area, or help them understand the importance or relevance of the topic being addressed. Always consider who your audience is before you make these decisions. For this lab, **your audience is likely to be knowledgeable about biology in general, but not necessarily about your specific topic area.** Your task is to write a scientific article that clearly explains your investigation, and its significance. Your instructor and fellow classmates, who are going to be more familiar with the instrumentation, methods, and specific topic area then the general intended audience, will be reviewing the initial draft of your article. This is a process sometimes referred to as **peer review** and is something that virtually all forms of published writing, including scientific articles, go through prior to publication. The process of peer review helps to establish the validity of your findings by allowing other people who are knowledgeable in your specific topic area to review your work and to identify strengths and possible weaknesses in your investigation which may require revision. Those articles that make it through this process, and are accepted as well-written, valid/trustworthy by knowledgeable peers, often get published in scientific journals. Your classmates will help you to write an article that is of sufficient quality to be published to a wider audience of current and future biologists. Additionally, your instructor will evaluate how well you can communicate and explain your research findings to a wider audience. So do not assume that your more general audience knows as much as your instructor or classmates about your topic area. Finally, remember that a good scientific article depends more on how well you can present and explain your results and their significance than it does on what results you obtained. Even if your investigation did not turn out as you expected, you can still write a good scientific article.

Sections of a Scientific Article

*Titles that are simply eye-catching, or cute, but not informative, are generally **not** appropriate for a scientific article.*

<u>Title</u>

Develop a concise title that clearly explains the focus of your research project (i.e. what you investigated). A good title is one that would give a person who is doing research in this area an initial indication of whether the project is relevant to their area of research. Therefore, good titles usually contain key words or phrases that allude to the scientific content or purpose of the article. Often you can use your experimental hypothesis to help you generate your title. For example, if your hypothesis is that elevated atmospheric oxygen levels will influence leaf primary productivity in plants that use the C3 photosynthetic pathways then your title could be:

The effect of elevated atmospheric oxygen levels on productivity in C3 plants.

The title should be centered at the very top of the first page of the article, and in bold font. Underneath it you should include the authors' names, and their affiliations, which is usually the institution where the research was conducted. For this class, your affiliation will be your college, your lab section, and your team's name.

<u>Abstract</u>

See the final section of this appendix for a more detailed description of how to write an

This section is generally written last, after you have completed your entire article. It is generally placed directly under the article title. In less than 300 words, the abstract presents a complete and concise summary of the research project. Include a brief statement of the problem or question examined, the hypothesis you tested, a very brief description of the methods, a summary of the important findings, and conclusions.

<u>Introduction</u>

The introduction should begin with a statement of the problem or research question. It should also provide relevant background biological information taking the reader in a logical progression to the statement of your hypothesis and experimental predictions. It should include an explanation of why this question is important or relevant to the field of biology, and/or to important biology-related issues (i.e. global warming, or pollution). Writing the introduction will require that you do some background research on the topic area in order to investigate the biological basis for the question, hypothesis and the methods chosen to test that hypothesis. The best place to start this research is your textbook for the course. However, you should also consult the primary literature (peer-reviewed journal articles available through the library). The introduction should contain parenthetical citations (which are then referenced in the Literature Cited section at the end of the article). The citation format used for the article you write is that developed by the American Psychological Association (APA). The following is an example of a well-written introduction.

Example Introduction

The authors clearly state the general purpose of the investigation and connect it to a larger issue, thereby capturing the reader's attention and establishing the significance or importance of their research.

The general purpose of this investigation is to explore the effect of elevated atmospheric O_2 levels on productivity in plants that use the C3 photosynthetic pathway. There are many biologists who are concerned that elevated global temperatures due to rising greenhouse gas emissions may have significant effects on photosynthetic rates in different species of plants. Plants that are better adapted to higher temperatures, lower rainfall, or perhaps changes in the concentrations of atmospheric gasses such as O_2 and CO_2 may fare better in a warmer world. This may have significant implications toward the understanding how global warming may affect plant communities in terrestrial ecosystems, and agricultural crop yields.

Including this background information helps to educate the reader about the biological basis for the investigation.

In terrestrial plants the carbon that is incorporated into organic molecules during photosynthesis comes from CO_2 from the atmosphere. During the Calvin cycle, and enzyme known as Rubisco catalyzes carbon fixation by adding carbon to a 5-carbon molecule (RuBP) to make two 3-carbon molecules of phosophoglycerate (PGA). Because the resulting product is a 3-carbon molecule the pathway is referred to as the C3 pathway (Freeman et al., 2014). It was found that during hot and/or arid periods, plants are forced to close their leaf stomata to avoid dehydration. When this occurs, O_2 concentrations inside the leaf can increase. Oxygen, which can also bind to the active site on Rubisco, can then begin to out-compete CO_2 for this site. This can result in photorespiratory release of CO_2 from the Calvin cycle, less efficient carbon fixation and therefore diminished productivity (Ogren 1984; Peterhansel et al. 2012).

Notice that supporting information is cited using a common citation format (APA style), and that the information is summarized in the authors' own words and not quoted directly from the original source.

There is evidence that elevated CO_2 levels can impact plant productivity (Beelow et al. 2004), and we are speculating here that world-wide changes in productivity may also influence atmospheric oxygen levels. So, the purpose of this study is to test the hypothesis that elevated atmospheric oxygen levels alone (induced without the corresponding elevated temperatures) will reduce both gross and net primary leaf productivity in a common ornamental plant (American holly - *Ilex opaca*) which use the C3 photosynthetic pathway. If accurate, this may have significant effects on agricultural productivity, the survival of natural plant species, and the extent to which farmers continue to shift to crops that use the C4 photosynthetic pathway, such as corn, even in areas less affected by increased global temperatures.

*The hypothesis is clearly stated, and is informed by prior knowledge/ research. Note: It is **not** "just a guess".*

Methods

In paragraph style, NOT as a bulleted list of instructions; describe the methods you used in the test of your hypothesis. Write in past tense. Focus on summarizing the important procedures used in the experiment with enough detail to allow someone to critique the experimental protocol or to repeat the experiment. Avoid presenting too much detail, or extraneous information that is not necessary to understand what you did to test your hypothesis. If parts of the methods are summarized in another source (i.e. one of the labs in the classes' lab manual), simply cite that source. For example:

The methods used to measure rate of CO_2 uptake or release using Vernier CO_2 gas sensors and LoggerPro Software were according to those presented in Peters (2015), pp. 53-55.

****Note** –After conducting the experiment you may have realized there were factors affecting the results for which you did not, or could not, account/control. If so, discuss this later in the discussion section, not in the methods section.*

Incorporate the materials into the description of the methods, as opposed to providing a separate list of materials. Be sure the methods also include:

- A statement of your independent and dependent variables, and units of measurement, number of trials/sample size.
- A description of the control group and experimental group, and how they were treated differently. Additionally discuss the variables held constant

across the levels of your independent variable (the different ways the groups were treated in the experiment), and how subjects were assigned to treatments.

- The statistical test you performed on your data (t-test; linear regression analysis).

It is generally best to avoid using personal pronouns (I, me, my, we etc…) as much as possible. For example it is better to say, "Approximately 10 grams of *American holly leaves were placed in the CO_2 gas sensor chamber…*", rather than, "*We placed 5 grams of American leaves in a CO_2 gas sensor chamber…*". Although the latter is not incorrect, the writing in the methods can become cumbersome and awkward if filled with too many personal pronouns. Since you are discussing the procedures you used in your study, you should also write in past tense.

Example:

> *Approximately 10 grams of leaves were collected from 10 different American holly (Ilex opaca) plants on campus. All leaves were free of visible insect or pathogen damage, and were collected immediately prior to testing. Leaf samples were then randomly assigned to the control (normal atmospheric O_2 levels – 21%) and high (26%) O_2 treatment.*

<u>Results</u>

Figures - Display your data in a format that concisely summarizes your findings. The easiest way to do this is through tables, graphs and other figures. It is usually best to summarize your data using descriptive statistics (i.e. mean, standard error or standard deviation). When using a figure or table, you should clearly refer to it in the text of the results and/or the discussion section. Use the information presented in the table to support your arguments.

Hint: Copy and paste your graph into your article as an image (i.e. jpeg) file. This allows you to resize the graph easily without changing the relative dimensions of different aspects of the graph.

All figures and tables should be clearly labeled and numbered sequentially in the order in which they are presented in the article. Tables should be numbered separately from figures (graphs, diagrams, charts etc…). There should be a clear description or title that describes its contents above the figure or table. All graph axes should be labeled clearly with units of measurement indicated.

All graphs should be computer generated (not hand-drawn) using appropriate software (i.e. MS Excel). Once graphs are constructed in MS Excel, you can highlight the graph, and copy and paste it into your article.

Reporting the results of your statistical tests. Report the statistical test performed (*i.e. a paired two sample for means t-test*), the value of the test statistic (i.e. $t = 2.71$), the sample size which can also be indicated by your total degrees of freedom (i.e. $df = 18$), and the probability value (i.e. $p = 0.001$). **<u>Do not cut and paste the entire</u> statistical test results table into the article**.

Additionally, present the conclusion(s) regarding the statistical hypotheses (null (H_o) and alternative (H_A)) in the results, and provide a brief interpretation of what this means in the context of the experiment and the overarching question being addressed in the study. Elaborate on this in the discussion section of the article. Consult the *Inferential Statistics Appendix* for more information on how to report the results of your statistical tests.

The text of the results - The text of the results should simply describe and highlight interesting or important findings or data trends that emerge from the data. Try to avoid redundancy. If a table or figure presents the findings clearly, then there is no need to restate these finding in the text of the results. Also avoid interpreting or speculating on possible causes of the results in this section. Save this for the next section (the discussion). (*Note*: the word data is plural, so you should say for example, "*The data <u>were</u> analyzed…*" rather than, "*The data <u>was</u> analyzed…*".

Below is an example of part of the results section written for the investigation discussed in the introduction presented earlier.

Example Results

The data presented in Figure 1 indicate that atmospheric O_2 concentration significantly affected both gross and net primary leaf productivity in the species of C3 plant examined in this experiment. A two-sample assuming equal variances t-test revealed that net primary productivity, measured as the rate of change in the biochamber CO_2 concentration in the light, was significantly lower (less negative) when leaves were exposed to elevated oxygen levels ($t_{one\text{-}tail}$ = -6.4; df = 18; p <0.01). It was also clear that the majority of the effect on net primary productivity was due to the diminished photosynthetic rates experienced by plants at higher atmospheric O_2 levels, and not, in the main, due to elevated respiratory rates which might be expected at higher O_2 levels (see respiration and GPP in figure 1). In fact, elevated atmospheric O_2 had no significant effect on respiratory rates in the species examined in this study ($t_{one\text{-}tail}$ = 0.82; df = 18; p= 0.21), while GPP, or total photosynthetic rate was significantly lower in the high oxygen treatment ($t_{one\text{-}tail}$ = 1.81; df = 18; p= 0.04).

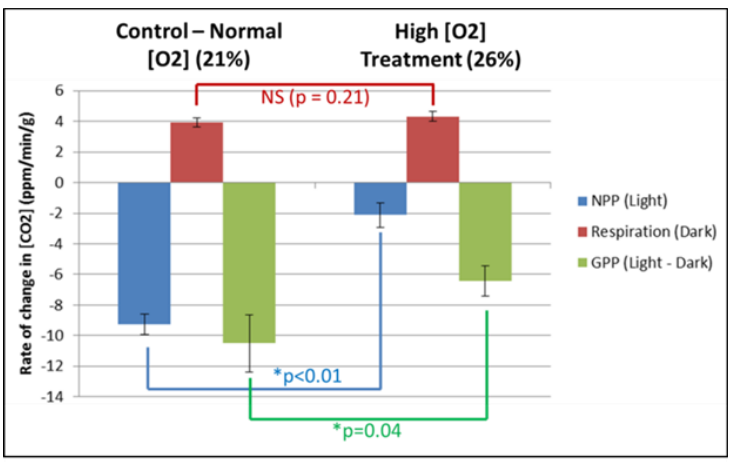

Figure 1. Comparison of mean (+/- 1 standard error) NPP, respiratory rate and GPP in American Holly leaves exposed to normal and elevated atmospheric O_2 concentrations. Note that higher rates of NPP and GPP correspond to greater negative values. *Significant and non-significant (NS) differences are indicated.

The author refers to the figure in the text of the results and points out important features.

Statistical test results and conclusions were concisely and correctly stated.

The graph has a description of its contents, axes and series are clearly labeled. Measurement units are included for the DV and IV, and the Y-axes scales are appropriate to allow full use of the graph space and to clearly delineated measurements.

Discussion

Complete all but the abstract and literature cited sections of your article BEFORE you begin to write your discussion. Start by giving a brief overview of the study's question, hypothesis and experimental predictions. Then discuss the following questions:

How do these data support or refute our hypothesis and are they consistent with the original predictions? Clearly and concisely explain this to the reader. Highlight specific results that led to your conclusions. Use the results of the statistical tests to make your argument. That is, interpret the results the statistical tests in the context of the experiment you performed. Explain your general conclusions regarding the investigation by referring back to the data you presented in your results. But most importantly, connect your conclusions to what you've learned about the biology of the organism! For example, stating that these data support your hypothesis is only half the story. Now you must make an argument for **why** you think this may have occurred. This will require the use of background research to support your argument. If the results led to conclusions that are different from those originally predicted, then you may have to do some additional background research to try to explain them.

What alternative conclusions are possible, and how do the data support other possible conclusions? It is here that you should speculate on other factors, which may have influenced your results. Describe the limitations of your experimental design and therefore their influence on the conclusions drawn from your data? What problems (there may be several) arose during data collection that may have influenced the validity (i.e. trustworthiness) or reliability (i.e. repeatability) of the results and therefore your conclusions? Finally speculate on suggested changes to the experimental design which could address these problems/limitations for future investigations.

The following is an example of a well-written discussion section.

Example Discussion

The results of our experiment confirm the hypothesis that elevated atmospheric oxygen can influence the net primary productivity of a common ornamental C3 plant even when no heat or water stresses are involved. Moreover the effect on net primary productivity occurred by diminishing photosynthetic rate rather than increasing respiratory rate (or a combination of the two). For the species of plant we tested net productivity decreased by an average of 7.11 ppm/min/g with a 5% rise in the atmospheric O_2 concentration (see Fig. 1). Although there was substantially more variation in GPP in both the control and treatment groups, most of this difference appears to be coming from diminished photosynthetic rates which were on average about 4 ppm/min/g greater in the low O_2 control group.

The authors clearly state that their results confirm their original hypothesis and predictions.

Data from their experiment is used to support their contentions.

The rate of photosynthesis in leaves can accurately be estimated by measuring the rate of uptake of CO_2 by the plant. During the daytime the leaves of plants take up CO_2 when the light dependent reactions are utilizing light energy to create the chemical energy (ATP and NADPH) necessary to create sugars during the light independent reactions (Starr 2006; Hopkins 1999). By measuring the rate at which plants consume or expel CO_2 during both photosynthesis and cell respiration, the total rate at which leaves harness the sun's energy for growth (net primary productivity) can be estimated (Hopkins 1999). In C3 plants, CO_2 combines with ribulose bis-phosphate (RuBP) to produces two 3-carbon molecules of phosphoglycerate (PGA). Competition between O_2 and CO_2 for the active site of the enzyme that catalyzes this reaction (rubisco) can result in photo-respiratory loss of CO_2 and lower overall output of sugars under high O_2 conditions in the leaf. This loss of CO_2 occurs because of the breakdown of organic compounds that were initially created during the C3 pathway (Calvin cycle). This can often occur when plants close their stomata to reduce loss of water under hot and arid conditions substantially elevating O_2 levels in the leaf (Ogren 1984; Freeman 2014). The results of this experiment indicate that even when O_2 levels in the atmosphere are artificially elevated above normal levels (rather than directly in leaf air spaces) there is a consequent effect on photosynthetic rate, and this translates in to lower net primary productivity. In fact it appears, that relatively minor elevation in atmospheric O_2 (a 5% increase) can significantly affect PR in the C3 plant species we tested (American holly – *Ilex opaca*).

The authors delve into the biological basis of their experiments, and the meaning of the data they collected. They then use it to explain why their results are consistent with their original hypothesis and predictions.

In the mid 1960's, an alternative photosynthetic pathway was discovered in sugarcane. This pathway, termed the C4 pathway (or syndrome), was initially identified by Kortschack et al (1965), and confirmed and further elucidated by Hatch and Slack (1966). Kortschack et al. (1965) found that a substantial concentration of CO_2, was initially incorporated into certain 4-carbon organic acids in sugarcane leaves, was showing up in sugars produced by the Calvin cycle in photosynthesis. Hatch and Slack (1966) proposed an alternative cyclic pathway by an enzyme called PEP carboxylase which catalyzes the addition of carbon from CO_2 to a 3 carbon molecule (PEP). The resulting 4-carbon molecule then shuttles carbon to the Calvin cycle. It is here that CO_2 is stripped from this molecule and is then incorporated into the C3 Calvin cycle pathway. This interesting metabolic adaptation has since been found mainly in plants that inhabit hot, arid tropical or subtropical environments and have a different leaf anatomy called Kranz anatomy (Raghavendra and Das 1978). The pathway is an adaptation that has allowed these plants to close their leaf stomata to minimize evaporative water loss (transpiration), while maintaining high enough CO_2 levels in the leaf to minimize photorespiration and maintain higher photosynthetic rates then C3 plants when exposed to similar hot/arid conditions (Hopkins 1999; Freeman 2014).

The authors extend their discussion of their results to other relevant biological concepts and discuss how their findings may relate to important other important questions or issues that are relevant to the study. Notice that this goes beyond that which was discussed in the article introduction.

The results of our experiment suggest that increased global temperatures alone may not be the only factor affecting the success of both wild and agricultural plants. As mentioned earlier, there is ample evidence that elevated atmospheric CO_2 levels can influence net productivity of plants (Beedlow et al. 2004). This increased productivity may have the consequent effect of elevating atmospheric oxygen levels, which our results suggest, that even in the absence of apparent heat or water stress, can diminish productivity. This can potentially counteract the effect of rising CO_2 levels on NPP, and therefore have significant influences on the types and diversity of species that inhabit natural ecosystems, favoring C4 plants that have the capability of dealing with heat and oxygen stress of a warmer/high CO_2 world.

However, it should be noted that the results obtained in this investigation are only preliminary in that we were unable to do many replicates (n=10 per treatment) due to time constraints in the lab. This low sample size precludes us from drawing more definitive conclusions. Additionally there are other factors that may have affected the results. In particular we noted that altering oxygen concentrations in our biochambers had the consequent effect of lowering the absolute CO_2 concentration. Although productivity was measured as rates of change in the uptake or release of CO_2 by the leaves, it is possible that the lowered absolute CO_2 concentration in the high O_2 treatments may have influenced photosynthesis in a manner that was independent of the photo-respiratory mechanisms discussed earlier. Moreover, we had no way of measuring the heat or water stresses experienced by our plants prior to collection. So given the low sample sizes, and our lack of knowledge of the plants' environmental conditions prior to collection, these finding should be considered with caution. Further investigations would benefit by working with plants raised under controlled conditions in the lab, and by examining this effect on a wider variety of C3 plant species.

Limitations of the experiment are addressed and suggestions for future improvements are provided.

Literature Cited

In this section, provide a list of the sources you cited within the text of your article (parenthetical citations). Although citation styles vary from journal to journal, the style required by the College of Charleston's *Journal of Undergraduate Biological Investigations (JUBI)* is that developed by the American Psychological Association - APA style. Duke University Library has an excellent web site which discusses the proper format for citing research sources (http://library.duke.edu/research/citing/). Here is a sample of a Literature Cited section from the above article. Note that the only sources that are cited below are those which are parenthetically cited in the text of the article.

Example Literature Cited

Beedlow, P.A., Tingey, D.T., Phillips, D.L., Hogsett, W.E., Olszyk, D.M. 2004. Front. Ecol Environ; 2(6): 315-322.

Freeman, S., Allison, L., Black, M., Podgorski, G., Quillin, K., Taylor, E., 2014. *Biological Science*. 5th Ed. Pearson, Boston MA.

Hatch, M.D. and C.R. Slack. 1966. Photosynthesis by sugar cane leaves. A new carboxylation reaction and the pathway of sugar formation. *Biochemical Journal 101:103-111*.

Hopkins, W.G. (1999). Introduction to Plant Physiology 2nd ed., John Wiley and Sons, New York, NY.

Kortschack, H.P., C.C.E. Hartt, G.O. Burr. 1965. Carbon dioxide fixation in sugarcane leaves. *Plant Physiology 40:209-213*.

Ogren, W.L. 1984. Photorespiration: pathways, regulation and modification. *Annual Review of Plant Physiology 35:415-422.*

Peterhansel, C., Krause, K., Braun, H.,P., Espie, G. S., Fernie, A. R., Hanson, D. T., Keech, O., Maurino, V. G., Mielewczik, M., Sage, R. F. (2012). Engineering photorespiration: Current state and future possibilities. Plant Biology 15 (4): 1438-8677

Peters, J. 2015. Discovering Biological Science: A Laboratory Manual for Biology 111. College of Charleston, Charleston, SC.

Raghavendra, A.S. and Das, V.S.R. 1978. Photochemical Characteristics of Mesophyll and Bundle Sheath Chloroplasts from C4 plants. Physiologia Plantarum. DOI: 10.1111/j.1399-3054

Writing Scientific Abstracts

The abstract should be the LAST part of the article you write, but should be the first thing presented in the article (right under the title; author's name(s)). An abstract is a single paragraph summary of the research article. Like a full scientific article it should contain an introduction, methods, results and conclusions, but these are not delineated by section headings, as in a full article. The purpose of the abstract is to let the reader know enough of the content of the article to make an informed decision as to whether the paper fits into the scope of the topic area he or she is researching. Additionally, the practice of using key words in an abstract is vital because of today's electronic information retrieval systems. Titles and abstracts are filed electronically, and key words are put in electronic storage. When people search for information, they enter key words related to the subject, and the computer prints out the titles of articles, papers, and reports containing those key words. Thus an abstract must contain key words about what is essential in an article, paper, or report so that someone else can retrieve information from it.

Qualities of a Good Abstract

- Uses an introduction/body/conclusion structure, which presents the article's purpose, methods, results, and conclusions, in that order.
- Follows strictly the chronology of the article, paper, or report.
- Provides logical connections (or transitions) between the information included.
- Adds no new information, but simply summarizes the report.
- Is understandable to a wide audience.
- Eliminates unnecessary words or phrases that do not contribute to conveying specific information about your research.
- Uses key words from your paper.
- Avoids personal pronouns like I, we, me, my, our… and use active rather than passive voice (Example: Correct: This article discusses… vs. Incorrect: In this article we discussed…)

Parts of the Abstract

Title and author(s):

> ***Krebs, C., Jones, L. and Darwin, K., 2005.*** *The effect of elevated atmospheric oxygen levels on productivity in C3 plants. College of Charleston, SC*

General topic: Write 1-2 sentences describing the general topic to be investigated and why it is important. Connect the research to real-world issues or scientific questions that may of direct relevance to your research question. For example:

> *Although elevated emissions of CO_2 have been shown to increase plant productivity, it is also possible that this may have the consequent result of increasing atmospheric O_2 concentrations.*

Specific Question or Relationship: Write one or two sentences describing the specific question you are addressing or relationship you are investigating with this investigation.

> *This study investigated the effect of artificially elevated atmospheric oxygen levels on gross and net primary productivity (GPP & NPP) in American holly (Ilex opaca), a common C3 plant.*

Method: Write one or two sentences describing the protocol for the investigation. Do not attempt to write a detailed procedure; just give a general idea what was done.

> *Oxygen levels were elevated to 26% by pumping O_2 from an oxygen tank into a standard Vernier biochamber. CO_2 gas sensors were then used to measure the rate of change in the concentration of CO_2 during a 10 minute light and then dark period for samples of American holly leaves. The data were then used to determine NPP, GPP and respiratory rate.*

Results: Write one or two sentences explaining the findings. Be as specific as possible. State only your main point(s).

> *NPP was significantly lower in leaves exposed to elevated oxygen levels ($p < 0.01$), and the majority of the effect was due to the diminished photosynthetic rates experienced by plants rather than elevated respiratory rates.*

Conclusions: Write a single sentence that summarizes conclusions about the general topic, question or relationship that was investigated.

> *This research suggests that even in the absence of apparent heat or water stress NPP can be diminished in the face of elevated atmosphere O_2 concentrations. This can potentially counteract the effect of rising CO_2 levels on NPP, and therefore have*

significant influences on the types and diversity of species that inhabit natural ecosystems.

The full abstract:

Krebs, C., Jones, L. and Darwin, K., 2005. The effect of elevated atmospheric oxygen levels on productivity in C3 plants. College of Charleston, SC

Although elevated emissions of CO_2 have been shown to increase plant productivity, it is also possible that this may have the consequent result of increasing atmospheric O_2 concentrations. This study investigated the effect of artificially elevated atmospheric oxygen levels on gross and net primary productivity (GPP & NPP) in American holly (*Ilex opaca*), a common C3 plant. Oxygen levels were elevated to 26% by pumping O_2 from an oxygen tank into a standard Vernier biochamber. CO_2 gas sensors were then used to measure the rate of change in the concentration of CO_2 during a 10 minute light and then dark period for samples of American holly leaves. The data were then used to determine NPP, GPP and respiratory rate. NPP was significantly lower in leaves exposed to elevated oxygen levels ($p < 0.01$), and the majority of the effect was due to the diminished photosynthetic rates experienced by plants, rather than elevated respiratory rates. This research suggests that even in the absence of apparent heat or water stress NPP can be diminished in the face of elevated atmosphere O_2 concentrations. This can potentially counteract the effect of rising CO_2 levels on NPP, and therefore have significant influences on the types and diversity of species that inhabit natural ecosystems