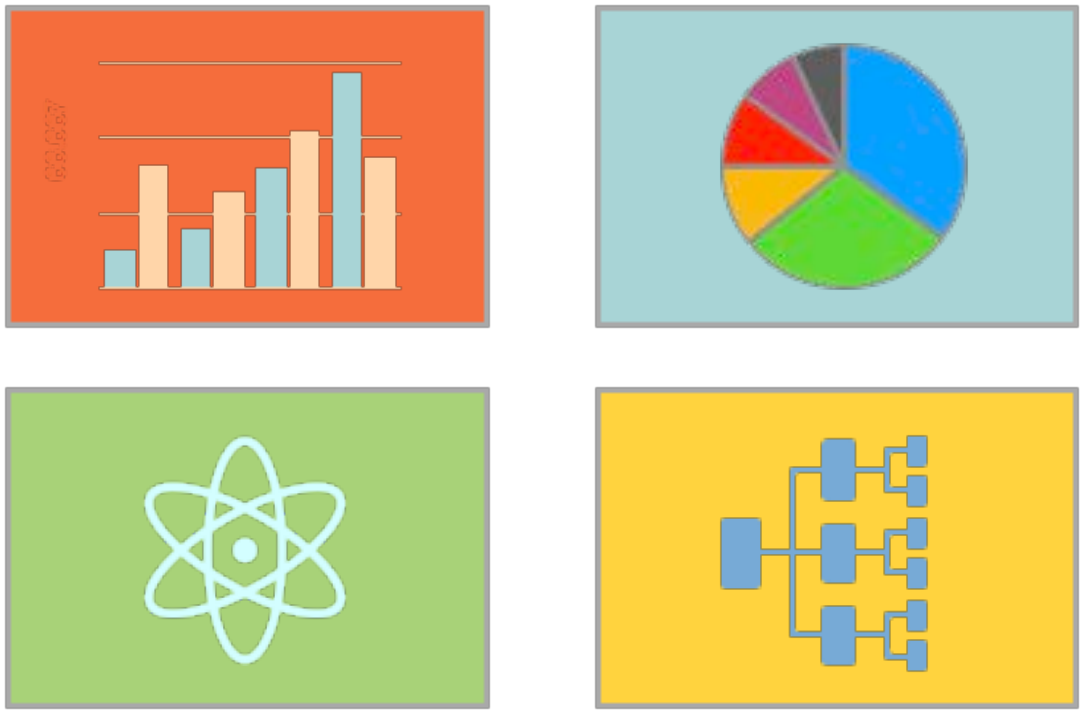
SCIENTIFIC POSTERS
CREATING AND PRESENTING



A Learner's Guide

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Scientific Posters

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Posters are used by scientists and engineers to communicate their research to the public. A scientific poster focuses on one defined research topic, question, or issue. It consists of the poster itself and a scientist who stands beside the poster and verbally presents their research to an audience of 1-5 people. A typical poster presentation lasts 5-10 minutes.

Scientific Posters

Characteristics Of A Scientific Poster

1. **Organized, clean, simple design.**
2. **Focused on one specific research topic that can be explained in 5-10 minutes.**
3. **Contains an Abstract, Introduction, Materials & Methods, Results, Discussion and References.**
4. **Has four to ten high-resolution figures and/or tables that describe the research in detail.**
5. **Contains minimal text, with figures and tables being the main focus.**

Scientific Poster

A scientific poster (**Fig.1**) is an illustrated summary of research that scientists and engineers use to present their scientific discoveries to larger audiences. A typical poster is printed on paper with dimensions of 36-inches (height) by 48-inches (width).

Posters are displayed at events such as symposiums, conferences and meetings to show new discoveries, new results and new information to scientists and engineers from different fields. A large event can have hundreds of posters on display at one time with scientists and engineers standing beside their individual posters to showcase their research.

Poster events are lively, loud and energetic. Attendees will walk around the event and stop at individual posters to interact with the poster presenter. The presenter and attendee will typically engage each other in 5-10 minutes of conversation as the presenter describes the research contained in the poster.

Poster events will typically last a few hours so that attendees have enough time to visit and interact with many posters and poster presenters. This is a good time for scientists to learn from one another and start new research collaborations that could one day lead to new discoveries.

Scientific posters are organized systematically into the following sections: Title, Authors, Abstract, Introduction, Materials and

Methods, Results, Discussion, Acknowledgments and References (**Fig. 1**). Organizing a poster in this manner allows the reader to quickly comprehend the major points of the research and to understand the significance of the work.

The most important parts of a scientific poster will likely be its figures and/or tables because these are what an audience will naturally focus their attention upon. The phrase "a picture is worth a thousand words" is certainly true for scientific posters, and so it is very important for the poster's author(s) to create informative figures that a reader can understand. The "ideal" figure can be challenging to create. Providing too much information in a figure will only serve to confuse the reader (or audience). Provide too little information and the reader will be left with an incomplete understanding of the research. Both situations should be avoided because they prevent a scientist from effectively communicating with their audience.

Authors use different fonts sizes for their poster text. The largest font sizes (e.g., 50-80 point font) will be used for the title, author list and institutions. Section headings will use 30-40 point font. Section text, table captions, figure captions and references will typically use 20-30 point font. Font sizes smaller than about 20-points should be avoided because it can be difficult to read.

Figure 1. Scientific Poster

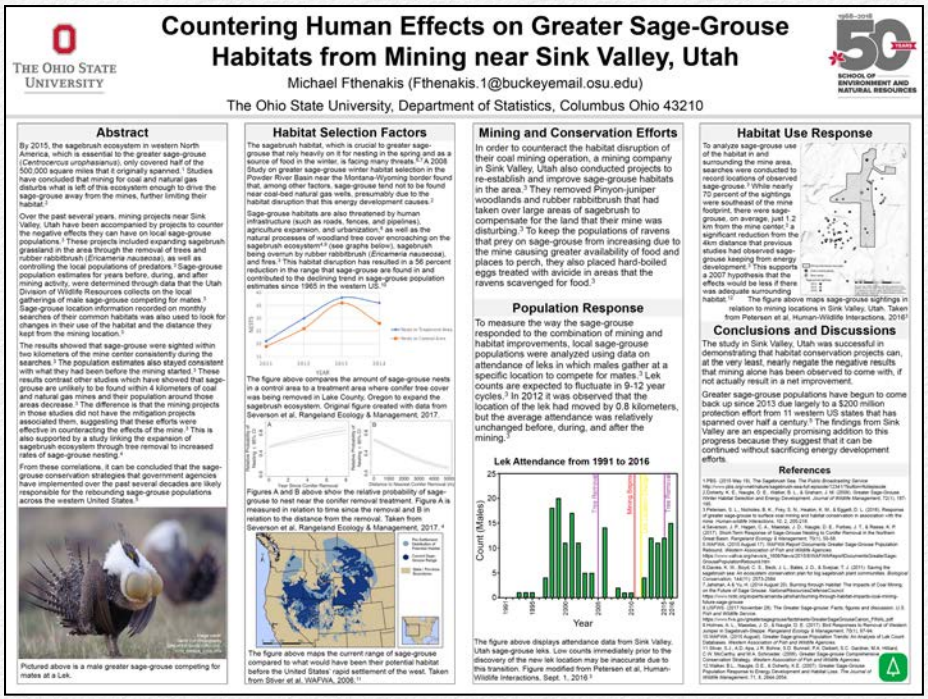

Figure 1. Example of a scientific poster focused on human-wildlife interactions in Utah. The poster is organized into rows and columns. When printed on paper, the poster will be 36-inches (height) by 48-inches (width). Title, author names and institution are listed at the very top of the poster in large font. Abstract (top left), introduction (bottom left), materials and methods (second column), results (third column), discussion (forth column), references (bottom right). Notice that your eyes are naturally drawn to the poster's figures and title. Note that the total word count (not including references) is approximately 1,000 words.

Parts of a Poster

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Posters contain several important parts including: Title, Author Names, Institutions, Abstract, Introduction, Materials & Methods, Results, Discussion, References, Figures, Tables and Acknowledgements.

Title

Characteristics Of A Title

1. **Informs the reader about what is contained within the poster.**
2. **Summarizes the most important research results and findings.**
3. **Simple and focused on the research.**
4. **Straight forward and matter of fact.**
5. **Clear and concise (e.g., less than 15 words).**
6. **Avoid words or phrases that sensationalize findings and results, convey bias or provoke human emotion.**

The poster title should appear at the very top of the poster (**Fig. 1**). The title should be brief (e.g., less than 15 words), descriptive and summarize the most important results and findings. Words, adjectives and phrases that covey bias or human feelings should be avoided. Scientists strive to let the data speak for itself and allow the reader the chance to make up their own mind about an issue based on the data that is presented.

For example, a poor title for a scientific poster would be something along the lines of: “Evil coal-fired power plants linked to dangerous mercury levels ruthlessly harm thousands of poor and defenseless children”. A much better title would be: “Mercury emissions from coal-fired power plants have been linked to decreased cognitive function in children”. The first title certainly catches your eye, but it presents the research in a biased manner before the reader even has a chance to examine the poster. The latter title tells the reader exactly what the poster is about while still allowing the reader the chance to read the poster and make up their own mind about the issue based on the data presented in the poster.

Authors & Institutions

People And Places

1. **Authors' names are typically listed in order of prominence.**
2. **Contact information for all authors (e.g., email, physical address, phone number) is provided.**
3. **This information tells the reader who conducted the research and where it was done.**

Authors are typically listed in order of prominence, with the person who completed most of the research appearing first in the author list and referred to as "first author". The "second author" would be the person who appears second in the author list and so on. The corresponding author is also often indicated on the poster and may appear as the last name in the author list. The corresponding author is the senior scientist who designed the research, supervised the work and obtained the funding to conduct the research.

The name of the college, university or institution where the research was conducted is also provided with the authors' names. For example: School of Environment and Natural Resources, The Ohio State University, 210 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210. The email addresses and phone number of the corresponding author is also provided.

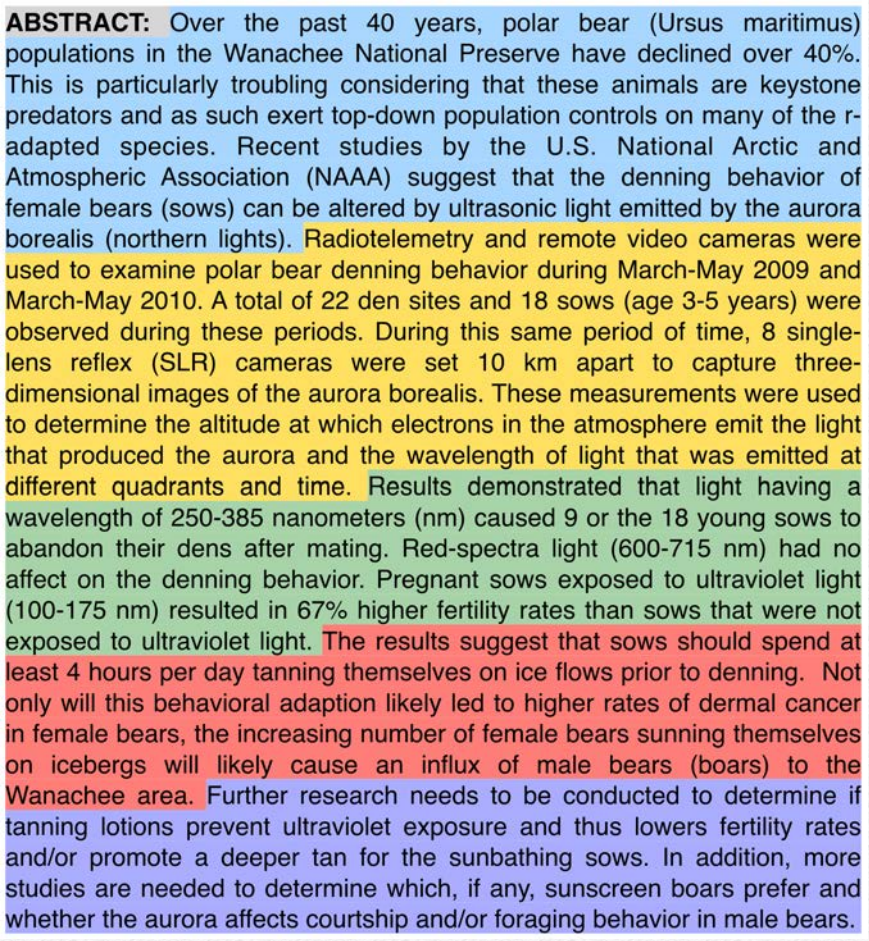
Abstract

The abstract is a paragraph of text that appears at the top-left side of the poster (**Fig. 1**). It is a summary of the entire poster. It should stand alone such that a person can read the abstract and understand all the research described in the poster. An abstract (**Fig. 2**) contains four parts that should be written in the following order: Introduction, Materials & Methods, Results and Discussion. Each part typically consists of 2-4 sentences and the entire abstract will contain 200-400 words. An abstract consists strictly of text, it contains no figures, no tables, and typically it does not contain citations.

Characteristics Of An Abstract

1. **One paragraph.**
2. **Typically 200-400 words long.**
3. **A summary of the entire poster.**
4. **Organized into four distinct sections that appear in order: Introduction, Materials & Methods, Results, Discussion.**
5. **Each section typically consists of 2-4 sentences.**
6. **No tables, no figures.**

Figure 2. Abstract



ABSTRACT: Over the past 40 years, polar bear (Ursus maritimus) populations in the Wanachee National Preserve have declined over 40%. This is particularly troubling considering that these animals are keystone predators and as such exert top-down population controls on many of the r-adapted species. Recent studies by the U.S. National Arctic and Atmospheric Association (NAAA) suggest that the denning behavior of female bears (sows) can be altered by ultrasonic light emitted by the aurora borealis (northern lights). Radiotelemetry and remote video cameras were used to examine polar bear denning behavior during March-May 2009 and March-May 2010. A total of 22 den sites and 18 sows (age 3-5 years) were observed during these periods. During this same period of time, 8 single-lens reflex (SLR) cameras were set 10 km apart to capture three-dimensional images of the aurora borealis. These measurements were used to determine the altitude at which electrons in the atmosphere emit the light that produced the aurora and the wavelength of light that was emitted at different quadrants and time. Results demonstrated that light having a wavelength of 250-385 nanometers (nm) caused 9 or the 18 young sows to abandon their dens after mating. Red-spectra light (600-715 nm) had no affect on the denning behavior. Pregnant sows exposed to ultraviolet light (100-175 nm) resulted in 67% higher fertility rates than sows that were not exposed to ultraviolet light. The results suggest that sows should spend at least 4 hours per day tanning themselves on ice flows prior to denning. Not only will this behavioral adaption likely led to higher rates of dermal cancer in female bears, the increasing number of female bears sunning themselves on icebergs will likely cause an influx of male bears (boars) to the Wanachee area. Further research needs to be conducted to determine if tanning lotions prevent ultraviolet exposure and thus lowers fertility rates and/or promote a deeper tan for the sunbathing sows. In addition, more studies are needed to determine which, if any, sunscreen boars prefer and whether the aurora affects courtship and/or foraging behavior in male bears.

Figure 2. Example of an abstract and its four parts: Introduction (blue), Materials & Methods (yellow), Results (green), Discussion (red) and optional Conclusion (purple). This abstract is provided merely as an example and is not factual nor is it based on actual research.

Introduction

Characteristics Of An Introduction

1. **Tells the reader why the research is important.**
2. **Provides background about the issue or topic that is being studied.**
3. **Sets the stage for the rest of the poster.**
4. **Informs the reader of the goals and objectives of the research.**

The Introduction section of the poster appears immediately after the Abstract (**Fig. 3**). It is used to introduce the reader to the topic and provide all the necessary information needed to understand the topic or issue. It describes the importance of the research, especially in context to previous work that has been conducted in this area. It helps to set the stage for the research described in the poster and provides clear objectives for why the work was conducted. If the work is being conducted in the environment, the introduction often provides information (e.g., biological and physical properties) about the ecosystem, its location on Earth (e.g., map) and other pertinent history about the field site (**Fig. 4**). If the work is being conducted in a laboratory setting, the introduction can provide information about the institution (e.g., name, location, mission, funding agency). The Introduction section (**Figs. 1 & 3**) frequently contains photographs of the organism and ecosystem that are being studied, a detailed map of the study site, diagrams or equations describing the topic or issue, and tables that help to organize especially complex data for the reader to better understand.

Most posters are divided into four columns with the Introduction section typically taking up 20% of the total area on the poster. You'll likely want to use 22-point to 26-point font in the Introduction section so that your audience can comfortably read the text. The total number of words contained in the Introduction

Figure 3. Scientific Poster

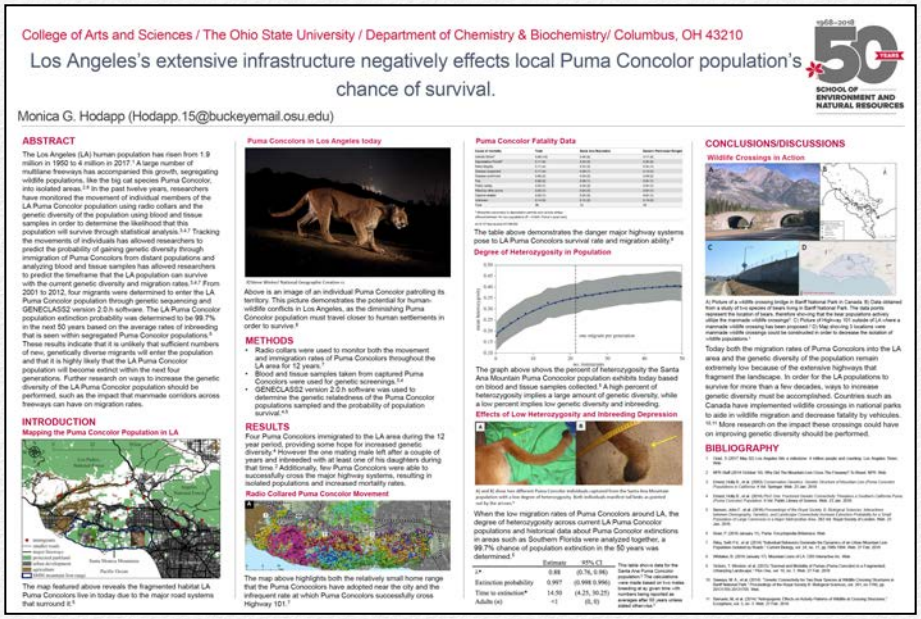


Figure 3. In this example poster you can see the Introduction section, which begins at the bottom of column one and continues into column two. It contains a high-resolution map of the study site (bottom of 1st column) and a high-resolution photograph of the study organism (mountain lion, top of 2nd column) at night walking through the ecosystem where the lion lives.

will likely be around 200 words and you will also want to include 1-2 figures (or tables) in this part of the poster (**Figs. 1 & 3**).

The audience will stand 2-3 feet away from the poster when viewing it. Figures, tables and text should be created so that they are easy to read and understand from this distance. To ensure that the Introduction section is easy to read, you should view the poster on your computer monitor at 100%, stand 2-3 feet away from the monitor and see if you can read the text, figures and tables. Anything that is difficult to read should be adjusted on your computer prior to printing the poster on paper, thus saving time and money. A font size of 22 to 26 points is a comfortable size to read on a poster from a distance of 2-3 feet away.

There may be a tendency to provide as much text and information as possible in your Introduction. You should avoid this temptation because you would need to decrease the font size below 22-point in order to fit more information on your poster. This will only serve to frustrate the reader with text that is too small to read. Remember that poster presentations consist of: (i) the poster itself and (ii) the person who is presenting the research. A presenter doesn't need to include all information in the poster, because they will be standing beside their poster talking to an audience and verbally communicating the information to the audience. Posters are tools that are used by scientists to explain their research using both visual and verbal communication. Some information will be visually communicated (e.g., **Fig. 4**), some information will be verbally communicated to an audience.

Figure 4. Introduction

The Bering Sea, off the west coast of the United States, is an extremely important ecosystem that provide resources to support large populations of shellfish, marine birds and mammals.[1,2] Climate change has caused the Bering Sea to warm over the past decade, negatively impacting populations of organisms that live at the bottom of the food chain and serve as a major food source for marine birds.[3,4] Tufted puffins (*Fratercula cirrhata*) spend the majority of their time near or in the Bering Sea and so their population is directly linked to the conditions of the Bering Sea.[3] The major food source for tufted puffins are juvenile herring and sand lance, which are small species of fish that feed on zooplankton living in the Bering Sea.[1,3,5] The recent increase in ocean temperatures have caused zooplankton populations to plummet resulting in dramatically low numbers of herring and sand lance for the tufted puffins to feed upon.[2,4] As a result, populations of tufted puffins have dropped by 25% in the past decade leading scientists to worry that these organisms could be extinct within the next 50 years.[2,3-5] The research presented in this poster examines how changes in zooplankton, herring, sand lance impact the reproductive success of tufted puffins living in the Bering Sea. The work also explores how changes in the geographical distribution of these tufted puffins has impacted other bird species living in the Bering Sea.

REFERENCES

1. Grebmeier et al., 2006, Science, 311(5766):1461-1464.
2. Golubova et al., 2009, Journal of Marine Biology, 35(7):593-608.
3. Flint, 2013, Marine Biology, 160(1):59-65.
4. Mizobata et al., 2010, Journal of Oceanography, 66(3):405-424.
5. Yeo et al., 2014, Climate Dynamics, 42(9-10):2423-2437.

Figure 4. Example of an Introduction, which provides the reader with the necessary information to understand the topic or issue and understand the importance of the research that is being described in the poster. References are also provided in this example.

Materials & Methods

Characteristics Of Materials & Methods

1. **Tells the reader how the research was conducted.**
2. **This section is used by other scientists as a guide to reproduce and critically evaluate the research.**
3. **Provides detailed information about the techniques, methods, instruments and equipment used in the research.**
4. **Tells the reader who conducted the research, how data was collected, when and where work was completed.**
5. **Gives information about the materials that were used in the experiments.**

The Materials and Methods section appears in the poster immediately after the Introduction section. It contains all the information needed to understand how data was collected, which instrument or equipment was used to collect data, what method or technique was used to conduct the research, when the work was conducted, who conducted the research, where the research was conducted, what material (e.g., chemical compound, organism, molecule, mineral) was used in the experiments and how or where the material was obtained. This information is important so that (1) the audience can understand how the research was conducted and (2) so that another scientist can attempt to reproduce the results. Reproducibility is a key component of the scientific process and a way that scientists can create new knowledge and understanding in their field.

The Materials and Methods section is matter-of-fact and simply states the facts of the research. For example, an author might explain how samples were collected from a field site: “One week after the August 2018 forest fire, 165 soil samples were collected from a depth of 0-5 cm at the White Wolf Campsite in Yosemite National Park. The samples were packed in ice, transported to the laboratory and then stored at -20^{o}C until processing. Samples were separated by size using a Wildco 78-700 Sieve Set (63 micron to 4000 micro, Cole-Parmer) and Meinzer II Sieve Shaker (Fisher Scientific).”

These sentences contain detailed information about where the samples were collected (i.e., Yosemite National Park, White Wolf Campsite) when (i.e., 1 week after the August 2018 fire) and how the samples were collected (i.e., at a depth of 0-5 cm) and handled (i.e., soil samples were stored frozen until they were separated by size using a sieve set and shaker). This is the type of information that should be contained in the Materials & Methods section of a poster.

The Materials and Methods section may contain a figure(s) that describes the research in more detail by showing the reader a photograph, diagram or equipment that was used for experiments (**Fig. 5**). Often times it is easier for the reader to understand how research was conducted or how data was collected when they have a figure to look at and study. **Figure 5** shows how the scientist collected samples from a freshwater lake (**Fig 5C**). The figure shows the location of the Pavilion Lake on a map (**Fig 5A**) and a photograph of the lake (**Fig 5B**) where samples were collected. **Figure 5D** shows the equipment that was used in the research and a photograph of the organism that the scientists were studying.

When describing a particular technique or method you should always provide a citation for the reference(s) that describes the technique or method in detail. This way your reader will be able to find detailed information about how experiments were conducted. You will be limited in the amount of information that can be provided in your Materials and Methods section because you will use 20-point font size or larger larger on your poster. You will also want to leave plenty of space on your poster for figures and tables because these are very important visual tools that you can use to describe your research to the audience.

Figure 5. Example of a Materials & Methods Figure

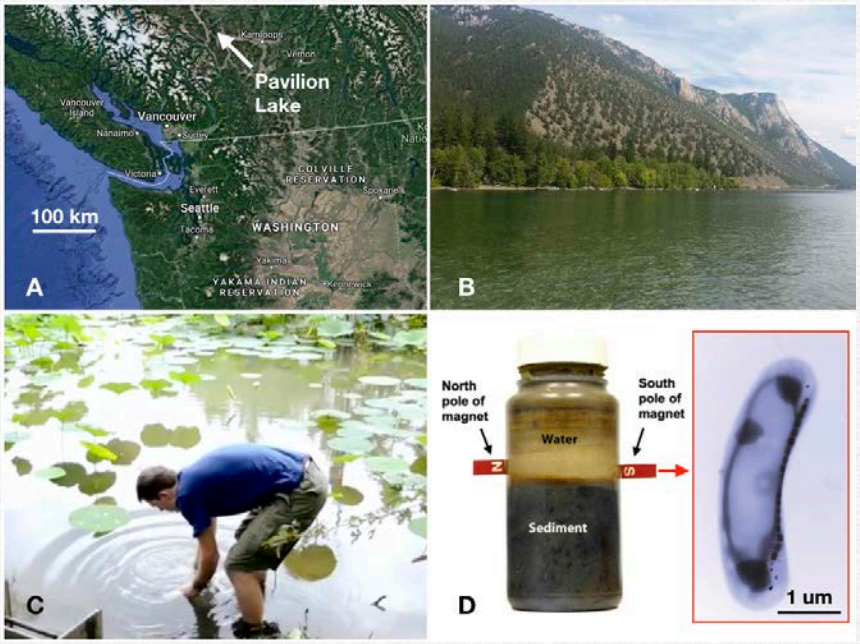


Figure 5. Collection and isolation of magnetotactic bacteria from Pavilion Lake. (A) Map showing the location of Pavilion Lake in British Columbia, Canada at 50.87º North, 121.74º West. Map obtained using Google Maps. The maximum lake depth is 70 meters, length is 5.75 km, maximum width is 0.8 km, and surface elevation is 820 meters. (B) Photograph of Pavilion Lake obtained from Google Maps and taken by S. Davies in August, 2016 near the location where water samples were collected. (C) Photograph of scientist collecting magnetotactic bacteria from Pavilion Lake. (D) Collection of magnetotactic bacteria from the lake, isolation of magnetotactic bacteria using magnets, and a transmission electron microscope image of a single bacterium. Images obtained from Oestreicher et al., 2013, Frontiers in Microbiology, Vol. 4, article 406, pages 1-6.

Results & Discussion

Characteristics Of A Results & Discussion

1. **Results section contains data collected by scientists from experiments that they conducted.**
2. **Data can be measurements, numbers, descriptions and observations.**
3. **Scientific data is typically described to the audience using graphs, tables, figures, diagrams, maps, charts, photographs and equations.**
4. **Discussion section provides an interpretation of the data, especially in context to previously published research.**

The Results and Discussion sections are often combined in a poster in order to (1) save precious space on a poster for the many pieces of information that a scientist would like to tell their audience and (2) by combining the two sections, it becomes easier for the audience to understand the significance of the research. Combining the Results section and Discussion section in a poster is different for what is typically done for a scientific journal article. In most journal articles, the Results section is separated from the Discussion section. Journal articles are different from posters in that a scientist is not standing next to their journal article explaining it to a reader. Therefore, in a journal article, an author needs to provide more detailed information so that the reader can understand the research. Separating the Results section and Discussion section allows an author the space necessary to write a lengthier description of the research. Journal articles typically contain more text and more content (e.g., figures, tables) than posters.

The Results and Discussion section should contain data, typically in the form of a graph, histogram, chart, image, color-coded map or table (**Figs. 1 & 3**). Very often data means numbers that scientists collect from making measurements. These data are typically presented to an audience in the form of graphs and charts to show a reader how these numbers change over time, space or experimental conditions (**Fig. 6**). Numbers can increase, decrease or stay the same and a graph,

or another type of figure, can be effectively used to convey this information to a reader in a visual format (**Fig. 6**).

An audience will be attracted to a poster because of its figures and so it is very important for the author to pay particular attention to the creation, design and placement of the figures in a poster (**Figs. 1 & 3**). A good figure is one that is informative, easy to comprehend and allows the reader to understand the significance of the data and experiment. Very often an author will use color to draw attention to a figure.

The Discussion section should state the importance of the research that is presented in the poster. It should provide an interpretation of the results, especially in context to previously published research. It may propose future experiments that need to be conducted as a result of the research presented in the poster. It should clearly illustrate the significance of the research with regards to new knowledge, understanding and/or discoveries that were made as part of the research.

Figure 6. Example of a Graph

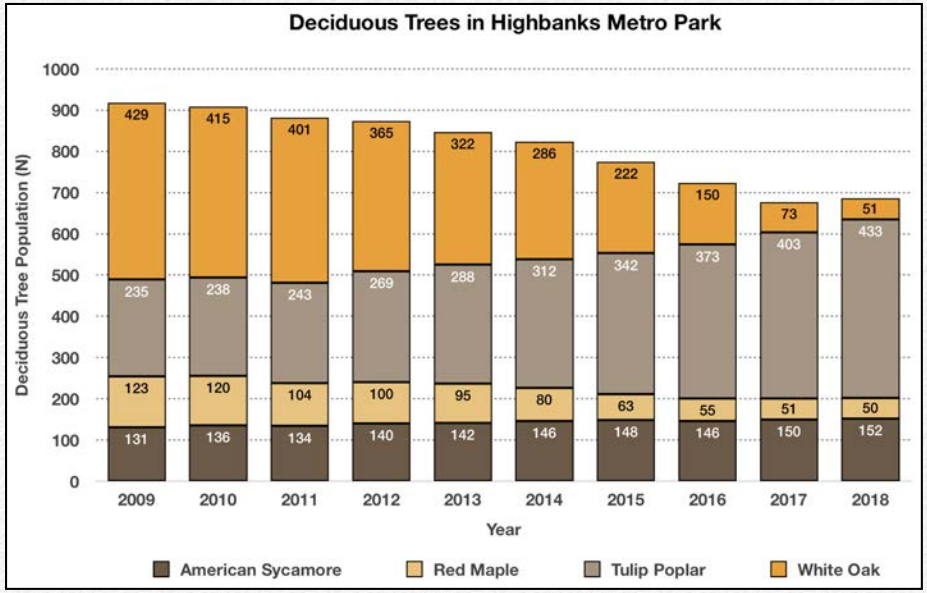


Figure 6. Graph showing how the population of different deciduous trees have changed from 2009 to 2018 in Highbanks Metro Park. Notice that the graph has a label for its x-axis (Year), a label for the y-axis (Deciduous Tree Population, N) and a key that shows, which color corresponds to which tree species (e.g., dark brown is American Sycamore).

References

Characteristics Of References Section

1. **Provide the reader with information about who conducted the research, when it was published and the journal that published the work.**
2. **Provides detailed information about author names, article title, journal name, volume, issue and page numbers so that readers can easily find the source of the information.**
3. **Acknowledge the scientist(s) who conducted the research and/or the journal article where the research was originally published.**

The References (or Bibliography) section should list all the sources of information that were used in the poster. This section appears at the end of the poster. The References section (**Fig. 7**) typically contains all journal articles (i.e., primary sources) but it can also contain secondary sources (e.g., newspapers, documentaries, government reports). References tell the reader where the original data, information, technique, and/or method can be obtained, who conducted the work and when the paper was published.

In posters, in-text citations are used to tell the reader where information was obtained. An in-text citation should appear after every sentence in the poster that describes the work of others. This includes all sentences that describe discoveries, findings, data, information, experiments, results, techniques, methods, dates, locations, etc.

In-text citations can be done using either (1) superscript numbers or (2) authors last name, followed by year published.

For example:

1. Polar bear cubs were 25% larger when fed a high-protein diet compared to high-sugar diet.[1]
2. Polar bear cubs were 25% larger when fed a high-protein diet compared to high-sugar diet (Jones and Smith, 2018).

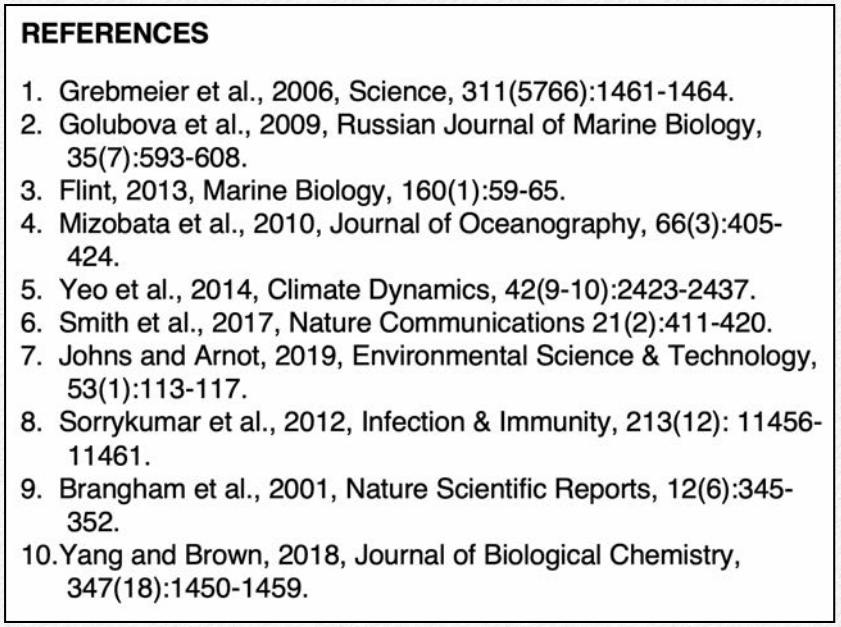
The “1” and “Jones and Smith, 2018” both refer to the same journal article: E.J. Jones and W. A. Smith (2018), Journal of Natural Science, Vol. 53, Issue 12, pages 36-45. Both types of in-text citations are acceptable for use in posters. Authors typically choosing superscript numbers to save space.

Formatting References

You have likely been taught about MLA (Modern Language Association of America) or APA (American Psychological Association) formatting and style guide in middle or high school. Many of you are likely proficient in these styles. For most posters you likely will not follow the MLA nor APA styles when citing your sources. There is a practical explanation for why these two styles often are not used in a poster. It is because there are thousands of different professional scientific societies around the world and each society has its own preferred formatting style that they use in publications for their journals and conferences. Therefore, citation styles will vary depending on where a poster is presented. In fact, many scientists use software, that, with a click of a button, will transform all of their citations into the proper style and format for any journal or conference.

Nonetheless, we provide 15 examples below of how one could cite primary sources (examples 1-5) and secondary sources (examples 6-15) of information in a scientific poster.

Figure 7. References Section of Poster.



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2. Golubova et al., 2009, Russian Journal of Marine Biology, 35(7):593-608.
3. Flint, 2013, Marine Biology, 160(1):59-65.
4. Mizobata et al., 2010, Journal of Oceanography, 66(3):405-424.
5. Yeo et al., 2014, Climate Dynamics, 42(9-10):2423-2437.
6. Smith et al., 2017, Nature Communications 21(2):411-420.
7. Johns and Arnot, 2019, Environmental Science & Technology, 53(1):113-117.
8. Sorrykumar et al., 2012, Infection & Immunity, 213(12): 11456-11461.
9. Brangham et al., 2001, Nature Scientific Reports, 12(6):345-352.
10. Yang and Brown, 2018, Journal of Biological Chemistry, 347(18):1450-1459.

Figure 7. References section of a poster that uses numbers 1-10 to indicate the source. Each reference contains the authors names, year published, name of the journal, volume number and page numbers. Reference 1 appears in the poster first, references 2 appears second and so on.

Citing Primary Sources

Peer-reviewed journal articles are considered primary sources. Patents and Published Technical Reports from Government

Agencies and Universities are also considered primary sources of information. Five examples of how to cite primary sources are numbered below 1-5.

1. Journal Article in Print (primary source): Most journals are printed on paper others are entirely available online. Authors Names. (Year Published in parenthesis). Article Title. Journal Name, Volume Number (Issue Number in parenthesis): Page Numbers.

> **1A. Journal Article with one or two authors:** McMurran, M. and Christopher, G. (2009). Bayes factors increases criminal sentence recommendations. Legal & Criminological Psychology, 14(1):101-107.

> **1B. Journal Article with more than two authors:** Post, E., et al. (2009). Genome studies of quorum sensing organisms. Science, 325(5946):1355-1358.

2. Online Journal Article (primary source): These journals are electronic and not printed on paper. Authors Names. (Year Published in parenthesis). Title of article. Journal name. Volume number and or page numbers. Include complete URL link in full or DOI if known.

> Dionne, M.S. and Schneider, D.S. (2002). Adaptive mutability in targeted microRNA infections. Genome Biol. 3:10.3559. http://genomebiology.com/2002/3/4/reviews/1010

3. Government Technical Report in Print (primary source): Author names or name of organization. (Year Published in parenthesis). Report title. Report Number. Name of government agency that published report, Place of publication.

> Smith, G.I. and Chen Y.P. (2018). Growth stages and tolerable fire intervals for Georgia's native vegetation data sets. Report no. 247. U.S. Department of Interior. New York, NY, USA.

4. Government Technical Report Published Online (primary source): Author names or name of organization. (Year Published in parenthesis). Report title. Report Number. Name of government agency that published report. Place of publication. Date retrieved followed by complete URL link in full or DOI if known.

> Spandone, H.K. et al. (2017). Energy futures for Midwestern wind farms. Report no. C2.4715.12. U.S. Department of Energy. Washington D.C., USA. Retrieved on February 15, 2017 from https://pdfs.semanticscholar.org/3e93/e8551981c644de300.pdf

5. Patent (primary source): Author names. Date in parenthesis. Title of patented item, technique, method or process. Patent number.

> Odell, J.C. (1970, April). Process for batch culturing. U.S. patent 484,363,770.

Citing Secondary Sources

Secondary sources report on and interpret results that have been presented in primary sources. Secondary sources include books, documentaries, magazines, newspapers, podcasts, webpages from government agencies and universities. Ten examples of how to cite secondary sources are numbered below 6-15.

6. Book Chapter (secondary source): Authors names. (Date of publication in parenthesis). Chapter title, page numbers. Editors of book, Book Title, Place of publication. Name of publisher.

> Forman, M.S., and Valsamakis, A. (2003). Specimen collection, transport, and processing: virology, p. 1227-1241. Murray, P.R., et al. (Eds.), Manual of clinical microbiology, 8th ed, Washington, D.C. Penguin Press.

7. Book (secondary source):

> Anderegg, D. (2007). Nerds: Who they are and why we need more of them. New York, NY. Jeremy P. Tarcher, Penguin Press.

8. Magazine Article in Print (secondary source):

> Road map to a great deal. (2009, October). Consumer Reports, 74(10), 44-47.

9. Magazine Article Published Online (secondary source):

> Taibbi, M. (2009, September 3). Sick and wrong. Rolling Stone, 1086, 58-65. Retrieved on February 22, 2020 from http://www.rollingstone.com

10. Newspaper Article in Print (secondary source):

> Lucchetti, A. & Craig, S. (2009, September 11). Morgan Stanley taps new boss. The Wall Street Journal, pp. A1, A16.

11. Newspaper Article Published Online (secondary source):

> Moran, S. (2009, September 7). If you don't snooze, you lose: Most Americans aren't getting enough sleep. And for both adults and students, there are health consequences.

Star Tribune. Retrieved on August 6, 2019 from http://www.startribune.com/

12. Podcast (secondary source):

Nature (Producer). (2009, July 16). Moon gazing in the Southern hemisphere, Audio podcast. Retrieved on November 5,2009, from http://www.nature.com/nature/podcast/index-2009-07-16.html

13. Documentary, Video or Movie (secondary source):

Donner, R. & Lee, S. (Producers), & Hood, G. (Director). (2009). X-Men Origins: Wolverine [DVD]. USA: Twentieth Century-Fox Film Corporation.

14. Personal Web Page (secondary source): In most instances a web page is not used as a reference in a poster.

Roszak, T. (1996, September). Why ecology needs psychology, why psychology needs ecology. Ecopsychology Online, 1. Retrieved on July 12, 2009 from http://ecopsychology.athabascau.ca/0996/ecowelcome.htm

15. Web Page of Organization or Group of Authors (secondary source): In most instances, a webpage is not used as a reference in a poster.

National Museum of American History. (2006, July 7). National museum of American history displays recent hip-hop acquisitions. Retrieved fromhttp://www.americanhistory.si.edu/news/pressrelease.cfm?key=29&newskey=383

Acknowledgements

Characteristics Of Acknowledgements

1. **List names of scientists who contributed to the research, but did not provide substantial contribution that would justify authorship.**
2. **List the funding sources (e.g., grant number, U.S. Government Agency) that made the research possible.**
3. **List names of research centers, institutions and organizations where research was conducted.**

One of the hallmarks of good science is to be open about the research and provide as much information as possible. This is also true when acknowledging the funding source for the research and names of scientists who contributed to the research. The Acknowledgements section typically appears last in a poster and is where an author will list the people who contributed to the research, but did not provide substantial contribution to the work that they should appear as a co-author on the poster. The Acknowledgments is also the section of the poster where the authors list the financial support for their research. These can include grants, contracts, fellowships or scholarships. The name of funding agencies who provided support for the research should be listed in this section. For example, an author may write: “Financial support was provided by the U.S. National Science Foundation, grant number EAR-012345”.

Complete Poster

Characteristics Of A Poster

1. **The poster itself should be written so that an audience can understand every part of the poster without needing the author to explain it.**
2. **Simple and clean design, organized, easy to read for a person standing 3-feet (1 meter) away from the poster.**
3. **Contains title, author list and contact information, abstract, introduction, materials & methods, results & discussion, figures & tables, references and acknowledgements.**

A complete poster should contains all the necessary parts and looks similar to **Figure 8**. Notice the order that each section appears in the poster with the Title, Authors and Abstract appearing first, followed by Introduction, Materials & Methods, Results & Discussion, Conclusion, References and Acknowledgements. A poster should also contain 4-8 figures (e.g., graph, histogram, chart, image, color-coded map) and/or tables. In **Figure 8**, five yellow boxes show the placement of each figure or table. A Figure Title is provided at the top of each yellow box and Figure Caption is typed below each yellow box (**Fig. 8**). When printed on paper, the poster shown in **Figure 8** will be 36-inches (height) by 48-inches (width). Most scientific conferences require posters match these dimensions.

Posters of this size must be printed on paper using large format poster printers, which are available at university bookstores, libraries, FedEx, UPS, retail stores (e.g. Staples, Walmart, Walgreens) and online services. Printing cost depends on a number of things (e.g., type of paper, type of ink, turnaround time) but is usually between $75-$150 (USD). Because of the high cost associated with printing a poster on paper, extra time should be spent checking over every detail of a poster before the author decides to send it for printing.

Figure 8. Example of a Complete Poster

Figure 8. Complete poster that contains all the essential parts. Title, Authors, Institution, Address, Abstract, Introduction, Materials & Methods, Results & Discussion, Conclusion (optional), References and Acknowledgements. Placeholders for Figures and/or Tables are shown with yellow boxes. Figure Captions are shown under each yellow box. Figures and Tables can be placed anywhere in the poster (except within the Abstract).

Scientific Literature

3

Primary sources are journal articles that describe the research of scientists and engineers. Journal articles go through a rigorous peer-review process before they can be published.

Secondary sources provide descriptions and analysis of journal articles and are typically reviewed by an editor prior to publication.

Finding Sources

Primary Sources & Secondary Sources

1. **Journal articles contains original research and data that must pass a rigorous peer review process before the article will be published for the public to read.**
2. **Scientists and engineers consider journal articles the primary source of information for scientific research.**
3. **Newspapers, magazines and documentaries are considered secondary sources of scientific information because they summarize the results and findings of journal articles.**

Finding Primary Sources

Primary sources are journal articles written by scientists and engineers and published in a journal. Journal articles are a full description of scientists' original research and contain an abstract, introduction, materials & methods, results and discussion. Journal articles are only published after they have successfully passed through a peer-review process prior to being accepted for publication. Rejected articles are not published and therefore the public never reads the article. High-impact journals are very selective and have high rejection rates. For example, a journal may accept less than 25% of all the articles that they receive. The remaining 75% are rejected during the peer-review process and never published.

There are two ways to find and read primary source journal articles. (1) The "old-fashioned method" of going to a library and physically finding and reading the journal article inside the library. (2) The "Internet method", which is the method that most people use today. This entails using a computer, connecting to the internet and remotely searching databases for an electronic copy of the journal article. The person is then able to download and read the article.

Some articles will be free to download and some articles will require a fee or subscription to the journal before you will be able to download an article. The good news for university students

is that they can freely access and download articles from hundreds to thousands of journals through their university library. This service is often included as part of a student's tuition and fees. Check with your library to see which journals you can accessed for free.

There are dozens of databases and search engines that can be used to find published journal articles. Five such services are:

1. PubMed (https://www.ncbi.nlm.nih.gov/pubmed/)
2. ScienceDirect (https://www.sciencedirect.com)
3. HighWire Press (http://highwire.stanford.edu)
4. Scopus (https://www.scopus.com)
5. Web of Science (www.webofknowledge.com)

The web-based search engine, Google Scholar (https://scholar.google.com) is also gaining favor due to its large capacity and ease of use. Because each search engine has its own limitations, it is always best to use multiple search engines to find journal articles. This will allow you to find more articles published by a wider variety of journals.

Finding Secondary Sources

Secondary sources are books, newspapers, magazines, video documentaries and podcasts that focus on the research contained within primary source journal articles. Secondary sources provide summaries, interpretations and evaluations of primary source journal articles. They are reviewed by editors or producers prior to publication (e.g., book, magazine, newspaper) or release (e.g., documentary film, podcast). The primary purpose of a secondary source is to inform and educate the public about new discoveries, findings and observations that scientists make during the course of their research. Secondary sources are typically published second, after the primary source is published. Secondary sources are easier to read and understand (compared to primary source journal articles) because much of the scientific jargon that was contained in the original journal article has been removed. This is done to appeal to a wider audience and make scientific discoveries and finding more accessible to the general public.

Finding secondary sources is easier than finding primary source journal articles because secondary sources are so widely available. These can be found on the internet, television, newspaper stands, libraries, coffee shops, trains, planes and basically anywhere where you find people. Secondary sources that have an established reputation of reporting facts in an unbiased and straightforward manner, checking these facts and correcting any errors are viewed as credible sources and typically have a large circulation and high readership. Some examples of well-respected secondary sources include:

6. BBC (https://www.bbc.com)

7. Chicago Tribune (https://www.chicagotribune.com)

8. Los Angles Times (https://www.latimes.com)

9. National Geographic (https://www.nationalgeographic.com)

10. National Public Radio (https://www.npr.org)

11. The New York Times (https://www.nytimes.com)

12. PBS Nature (https://www.pbs.org/wnet/nature/)

13. PBS NOVA (https://www.pbs.org/wgbh/nova/)

14. Reuters (http://www.reuters.com)

15. Scientific American (https://www.scientificamerican.com)

16. The Seattle Times (https://www.seattletimes.com)

17. Smithsonian (https://www.smithsonianmag.com)

18. USA Today (https://www.usatoday.com)

19. The Wall Street Journal (https://www.wsj.com; despite its name, the WSJ is indeed a newspaper and not a journal)

20. Washington Post (https://www.washingtonpost.com)

Primary Sources

Peer-Reviewed Journal Articles

1. **Primary Sources are peer-reviewed journal articles.**
2. **Journal articles go through a rigorous peer review process prior to publication.**
3. **Seen as the most trusted and well-respected sources of scientific information.**
4. **Provide a first-hand account of the research.**
5. **Primary sources can also be patents and technical reports published by government agencies.**

Primary Sources

Most sources used in a scientific poster come from primary sources (**Fig. 9**). Primary sources are peer-reviewed journal articles that have successfully passed through a rigorous review process prior to publication. Only after a manuscript (it's not referred to as an article until it is published) has successfully passed through this process will it be published.

Many high-impact journals are very selective in determining whether to publish a manuscript. Some journals are so selective that they reject greater than 90% of all manuscripts they receive. If a manuscript is rejected, the public will never see or read about the research. Because journal articles have gone through a rigorous peer-review process, they are seen as the most trusted and well respected sources of scientific data and information.

Primary sources are **journal articles** that have been written by professors, scientists and engineers then submitted to a journal for publication. These professionals are the original source of information discussed in the article. A scientist will (1) conduct research, (2) write a manuscript describing their research and its findings and then (3) send the manuscript to a journal requesting that it be considered for peer review and potential publication. A journal editor reviews the manuscript to determine whether to send it out for a full peer review. If it meets their

standards then the manuscript is sent to 2-5 experts in that particular field of research. These experts take a few weeks to review the article and make a recommendation to the editor about whether the manuscript is acceptable for publication. Experts are often critical of a manuscript and the research that is presented in the manuscript. It is common, especially for high-impact journals, that peer reviewers advise the editor to reject the manuscript outright. If this happens, the manuscript is sent back to the authors and the public never reads about the research. The authors must conduct additional experiments, rewrite their manuscript and then submit a revised manuscript back to the same journal, or often another journal. Then the entire peer review process starts all over again.

High impact journals (e.g., Science, Nature and Proceedings of the National Academies of Science, PNAS) set high standards for success and will reject the vast majority (e.g., greater than 75%) of all manuscripts that they receive due to unfavorable reviews. Typically, the higher a journal's impact factor, the higher its rejection rate.

Examples of Primary Sources

1. Science http://www.sciencemag.org
2. Nature http://www.nature.com (**Fig. 9**)
3. PNAS http://www.pnas.org

There are thousands of professional journals that publish hundreds of individual articles each year. Scientists have been publishing articles in journals for hundreds of years. This works out to millions of published articles contained within all these journals. Therefore, the best way to find journal articles that are of interest to you is to use a computer and a search engine.

Figure 9. The Journal Nature.

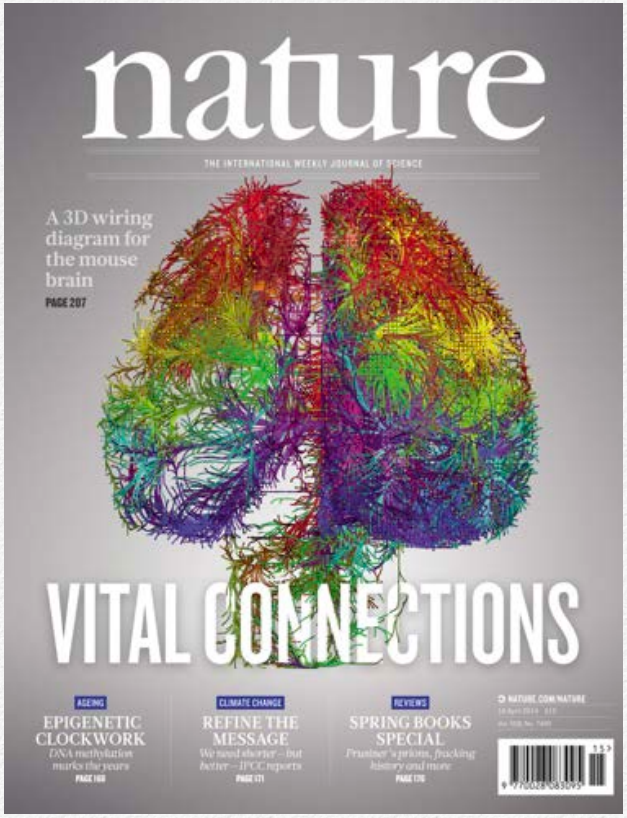

Figure 9. Nature, which is a journal and a primary source. Shown is the cover for Volume 508, Issue 7495, publication date 10 April 2014. Link: https://www.nature.com/nature/volumes/508/issues/7495 .

Scientific Journal Articles

A scientific journal article is a first-hand account of new research that has been conducted by scientists and engineers. It has went through a rigorous peer review process and been deemed worthy of publication. Journal articles function to communicate scientific research with the public. Some journals are published weekly while other journals are publish bimonthly or monthly.

Journal articles follow a standard format that includes: title, author names, abstract, introduction, materials & methods, results, discussion, acknowledgement and references (**Fig. 10**). Articles also contain figures and tables that are used by the authors to effectively communicate data and results to the reader. This standard format makes it easy for the reader to find and understand each part of the research. This standard format is also followed by scientific posters.

Peer Review

A research article that has been published in a journal went through a rigorous review process where experts (i.e., peer scientists) evaluated the article and deemed the research worthy of publication. This process is referred to as scientific peer review. It is done to ensure that the research is original, that experiments are conducted in an appropriate manner, that data support results and conclusions and that articles meets quality standards set forth by the publisher. Only those articles that successfully pass through the peer review process are published and read by the public. Articles that don't make it through the peer review process are rejected, not published

Figure 10. An Example Journal Article.

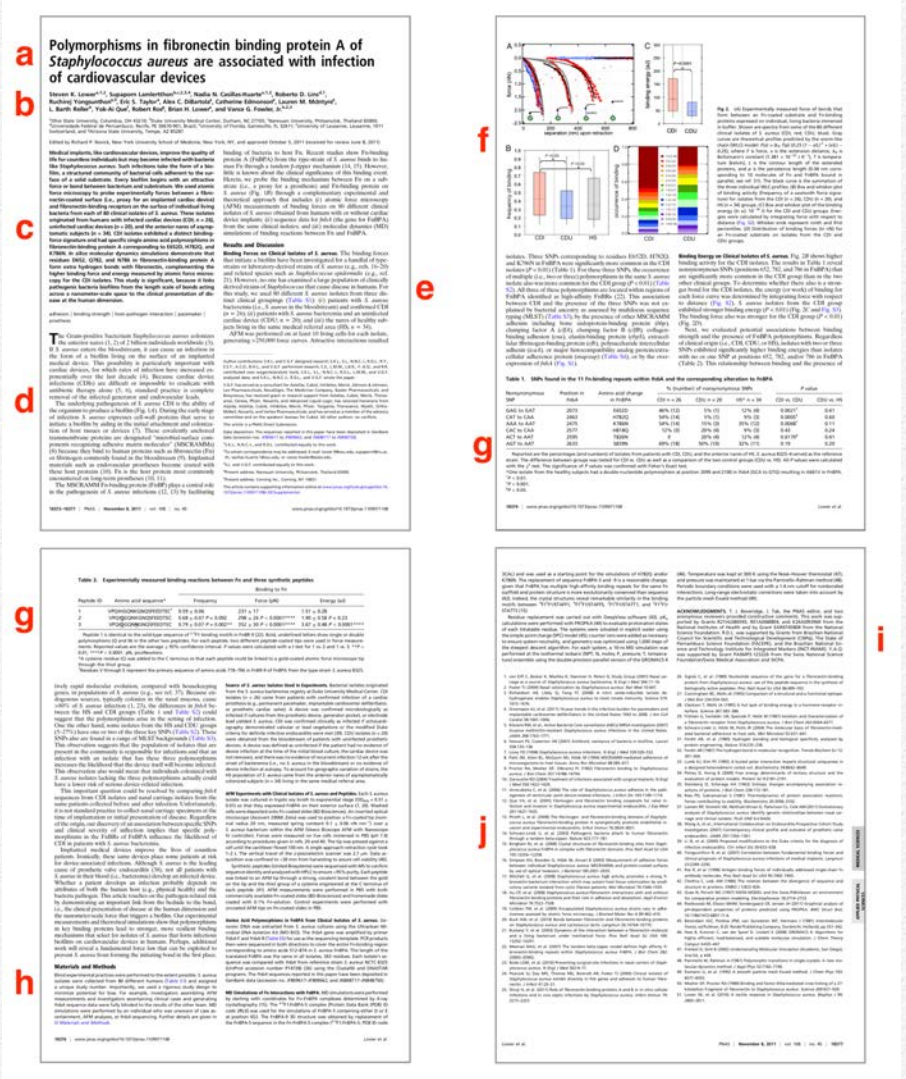

Figure 10. Example of a journal article (Lower et al., 2011, PNAS, 108(45):18372-18377) and its different parts. (a) title, (b) author names, (c) abstract, (d) introduction, (e) results & discussion, (f) figure, (g) table, (h) materials and methods, (i) acknowledgements and (j) references.

and therefore are never read by the public.

The basic steps of the peer review process are shown in **Figures 11**. (Step 1) Dr. Brutus Buckeye is a professor at Ohio State University (OSU) who has completed his research, wrote a paper about his findings and wants to publish his paper in the Journal of Natural Systems. (Step 2) Dr. Buckeye sends his paper to Dr. Tina Traveler who is a professor at the University of Southern California (USC) and an editor for the Journal of Natural Systems. Dr. Traveler reads the paper to determine if the research is original, significant and appropriate for publication in the Journal of Natural Systems. Dr. Traveler will either reject the paper outright or send the paper to several experts to evaluate. A paper is typically reviewed by 3-5 experts. (Step 3) In this example (**Fig. 11**), Dr. Olivia Oxley (professor at University of Oxford), Dr. Dan Bulldog (professor at Yale University) and Dr. Roberto Floresta (professor at Universidade de Sao Paulo) agree to review the paper. The three professors read the paper and write a thorough and detailed review of the paper. They send their reviews to the editor (Dr. Traveler) and recommend that the paper be accepted or rejected. (Step 4) The editor (Dr. Traveler) reads all three reviews, their recommendations and then makes an overall decision to accept or reject the paper for publication in the Journal of Natural Systems (**Fig. 12**).

Figure 11. Peer Review Process.

Figure 11 shows how the peer review process works for a scientific paper. Each reviewer provides a detailed evaluation of the paper that includes a recommendation to accept (thumbs up) or reject (thumbs down) the paper. An editor will read these reviews and make an overall decision to accept the paper for publication in the journal, request a revised paper from the author that will go through the peer review process again, or reject the paper. The public will only be able to read those papers that have been accepted for publication.

Figure 12. Peer Review Outcomes

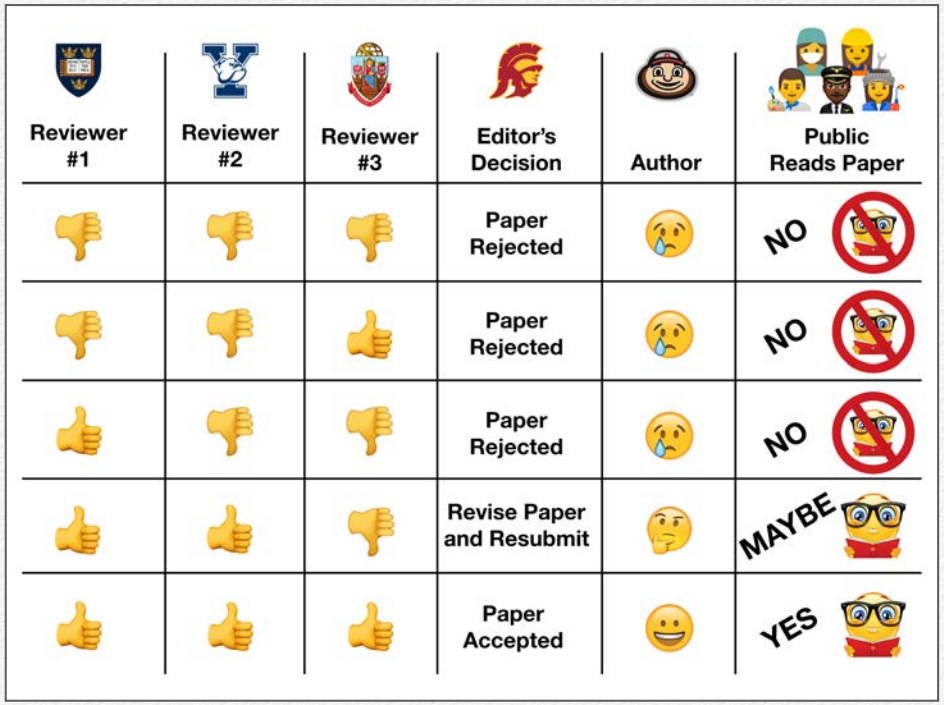

Figure 12. Decision to accept or reject a paper for publication in a journal.

Secondary Sources

Newspapers, Magazines, Public Media, Textbooks

1. **While secondray sources do not go through a peer review process, they are reviewed by authors, editors and producers prior to publication to ensure high quality.**
2. **Secondary sources report on and interpret results that are presented in primary sources.**
3. **These are typically easier to read and understand when compared to primary source journal articles.**
4. **Secondary sources typically do not provide the level of detail that is reported in a primary source.**

Secondary Sources

Other sources that may be used for a scientific poster are secondary sources, which generally refer to newspapers (**Fig. 13**), radio programs, news programs, documentaries, videos, magazines and some government sources. Secondary sources report on and interpret results that have been presented in primary sources. Secondary sources generally have not been peer reviewed, however, they have been reviewed by editors, writers and producers prior to publication because the publisher wants to maintain a high degree of integrity with their work and publications.

Just because a secondary source has not been peer reviewed does not mean that it is an inferior source of information compared to peer-reviewed journal article. Many secondary sources are very well respected and excellent sources of information. These publications (e.g., newspaper, magazine, documentary) are used to provide information that has originally been presented elsewhere (e.g., in a journal article, or during a talk at a professional conference). These articles are often reviewed by an editor(s) prior to publication to ensure that the information is credible and the story is accurate. Just as is the case for journals, a strong reputation for accurately reporting facts and information is one of the main goals that publishers strive to achieve. Those that have developed a trust with the general public because they have a strong reputation for unbi-

ased reporting are generally well respected as sources of trustworthy information. Secondary sources are usually easier to read and easier to understand when compared to primary sources.

Highly respected newspapers (secondary sources) like the New York Times, the Wall Street Journal and the Washington Post have an extensive editorial staff and professional writers to ensure high quality articles. In addition to newspapers, textbooks, magazines (e.g., National Geographic, Scientific American, Smithsonian), public broadcasters (e.g., NPR, PBS), broadcast television networks (e.g., ABC, CBS, NBC, Fox) are all excellent secondary sources.

Examples of Secondary Sources

1. New York Times http://www.nytimes.com (**Fig. 13**)
2. National Geographic http://www.nationalgeographic.com
3. Mainstream science textbooks
4. National Public Radio http://npr.org
5. PBS Nature http://www.pbs.org/wnet/nature/
6. PBS NOVA http://www.pbs.org/wgbh/nova/
7. PBS FRONTLINE http://www.pbs.org/wgbh/frontline/
8. Scientific American http://www.scientificamerican.com

Figure 13. Secondary Source Newspaper

"All the News That's Fit to Print"

The New York Times

Late Edition

VOL. CLXV . . . No. 57,029 © 2015 The New York Times NEW YORK, SATURDAY, OCTOBER 24, 2015 $2.50

HURRICANE SLAMS COAST OF MEXICO WITH HIGH FORCE

BRINGS 165-M.P.H. WINDS

Storm Barrels Inland — Extensive Damage and Flooding

F.B.I. CHIEF LINKS EYES ON POLICE TO RISE IN CRIME

AN UNSETTLED THEORY

Sharp Dispute Over Any Credence to the 'Ferguson Effect'

A Syrian Family Swept Up in a Migrant Tide to Europe

Many Obstacles Await on Perilous Quest for Safe Haven

3 Directors Say VW Hid Deceit From the Board

Sotheby's Pulls Out All the Stops

Right-Wing PACs Vilify G.O.P. Elite, and It Pays

Bush Cuts Costs, Carson Eclipses Trump in Iowa and G.O.P. Frets

Figure 13. The New York Times, which is a newspaper and a secondary source. This issue was published on October 24, 2015.

9. Washington Post https://www.washingtonpost.com

10. ABC News https://abcnews.go.com

U.S. Government Sources

U.S. government agencies and departments can also be excellent sources of scientific data and information. These agencies publish both primary sources and secondary sources of information. Several examples that are useful to science and technology are listed below. Each agency or department focuses on a particular field. For example, the USDA focuses on agriculture and NOAA focuses on weather and climate.

1. Centers for Disease Control and Prevention (CDC) http://www.cdc.gov
2. National Aeronautics and Space Administration (NASA) https://www.nasa.gov
3. National Institutes of Health (NIH) http://www.nih.gov
4. National Oceanic and Atmospheric Administration (NOAA) http://www.noaa.gov
5. National Park Service (NPS) http://www.nps.gov
6. Department of Agriculture (USDA) http://www.usda.gov
7. Department of Energy (DOE) http://www.energy.gov
8. Department of Interior (DOI) https://www.doi.gov
9. Environmental Protection Agency (EPA) http://www.epa.gov
10. Fish and Wildlife Service (FWS) http://www.fws.gov
11. Food and Drug Administration (FDA) http://www.fda.gov
12. Geological Survey (USGS) http://www.usgs.gov
13. National Science Foundation (NSF) http://www.nsf.gov

These agencies and departments employ thousands of scientists and engineers who conduct research and then report their finding back to the general public. They communicate their discoveries and results with the general public through technical reports, guidelines, recommendations, podcasts, seminars, presentations and primary source peer-reviewed journal articles.

For example, **Figure 14** shows how the U.S. Environmental Protection Agency (EPA) informs the public about the dangers of polychlorinated biphenyls (PCBs) and their efforts to cleanup PCB waste in the USA. This webpage, shown in **Figure 14** (https://www.epa.gov/pcbs/epa-regional-polychlorinated-biphenyl-pcb-programs), is constantly updated with the EPA's most recent data, results and discoveries so that people can stay informed and make informed decisions in their daily lives. This webpage would be considered a secondary source. Links to primary source journal articles, secondary source guidelines and fact sheets and regional PCB clean up programs are all provided on the website (**Fig. 14**).

Figure 14. EPA Website

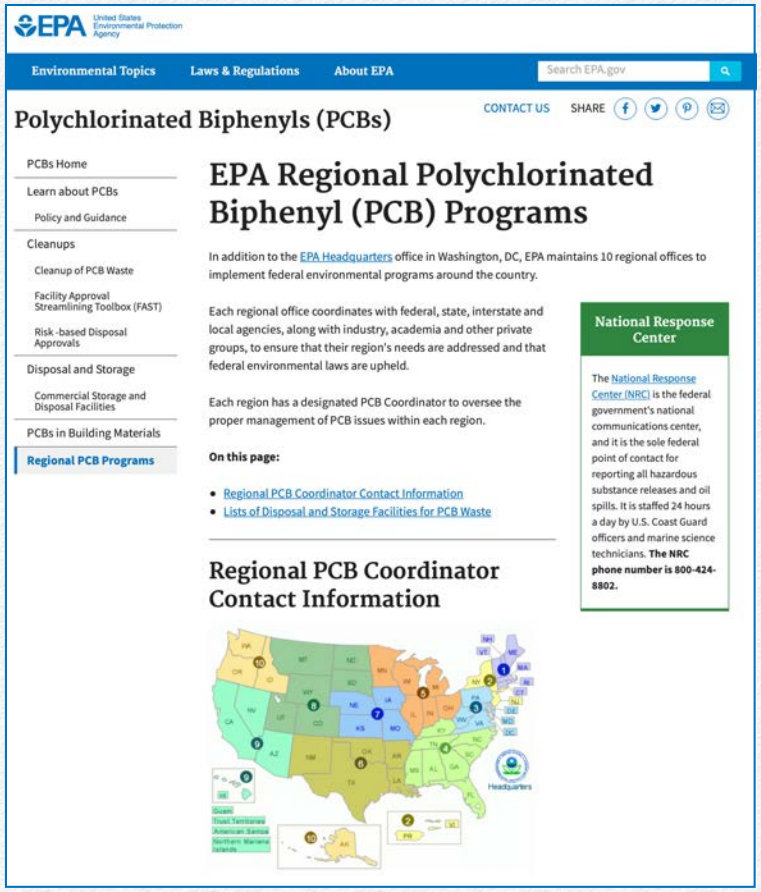

Figure 14. The U.S. Environmental Protection Agency's PCB Programs webpage. This webpage contains links to both secondary and primary sources of information for the public. Link: https://www.epa.gov/pcbs/epa-regional-polychlorinated-biphenyl-pcb-programs

Figures & Tables

4

Figures and tables are used by scientists and engineers to communicate large amounts of data to an audience. They serve as efficient and effective ways to show findings, results and trends in a visual format.

A figure can be a chart, diagram, data plot, graph, image, map, photograph or schematic.

Figures & Tables

Characteristics Of Figures & Tables

1. **High quality (typically a resolution of at least 300 dpi) figures should be included in a poster so that the audience can easily read and understand the importance of the research.**
2. **An audience will focus most of their attention on a poster's figures and tables, therefore it is important to provide high-quality and informative figures and tables.**
3. **Figures can be illustrations, images, diagrams, photographs, graphs, charts, plots and maps.**
4. **Tables are used to communicate large amounts of data in a concise and effective manner.**

Poster Figures

Figures are visual representations of data and information that allows an audience to better understand the research contained in a poster. A figure should always be accompanied by a caption that describes the information contained in the figure (**Fig. 15**). Figures are important elements of all scientific posters and assist scientists in conveying research results and describing important details about their research topics. Figures can be illustrations, charts, graphs, maps, plots, diagrams and photographs. A scientific poster contains multiple figures (typically 4-8) used to describe the research data. However, there should not be so many figures that they take up the entire poster. Between 4-8 figures (or tables) is a reasonable number of figures (or tables) to include in a poster. The exact number will depend on the overall poster design and research objectives, which will be different for each presenter and each poster.

Poster Figure Considerations

1. Figures should be high quality and high-resolution images. A resolution of 300 dpi is typically recommended.

2. You should include a variety of figures in your poster, such as photographs, images, graphs, maps, diagrams, charts, etc.

3. It is encouraged that you include original figures that you designed, created or photographed.

4. Each figure needs to be accompanied by a figure caption that describes the figure. Figure captions should be short (that is, typically less than 100 words) and descriptive.

5. Each figure should contain a citation(s), which references the original source of data/information presented in the figure.

6. Figures are used to engage an audience and capture their attention. This can be done through the use of color (as opposed to black and white), high-resolution images and photographs, visually stimulating presentations, or graphs and illustrations that explain complex information in a clean and simple manner.

Poster Tables

Tables are use to organize large amounts of data (e.g., numbers, information, observations) into rows and columns so that an audience can more easily understand the research (**Table I**). Like a figure, a table is an important part of a scientific poster. It serves to communicate the importance of a particular data set or results to an audience. When viewing a poster, most people will be drawn to figures and tables first and they may not read the text contained in the body of a poster but rather focus all their attention presented in a poster's figures and tables. Therefore, it is important that a table be designed and presented in a way that effectively communicates important data and results to the audience.

Poster Table Considerations

1. Tables should be clear, concise with data divided into well defined categories.

2. Columns and rows should be spaced so that data contained within the table is easy to read.

3. Units of measurement (e.g., kg, meters/second) should be included.

4. A caption should accompany each table to explain the data and information contained within the table.

5. Each table should contain a citation(s) that references the source of the information presented in the table.

6. A minimum of 20-point font should be used in the table so that an audience can read from a distance of 2-3 feet (1 meter).

Figure 15. Different Types of Figures.

Figure 15. Posters use different types of figures to communicate results to an audience. Figures help the audience visualize the information and data contained within the text. Figures can be images (A), maps (B), flow charts (C), line and bar graphs (D), photographs (E) and diagrams (F). A figure caption should accompany each figure to provide a complementary explanation of the data and information contained within the figure.

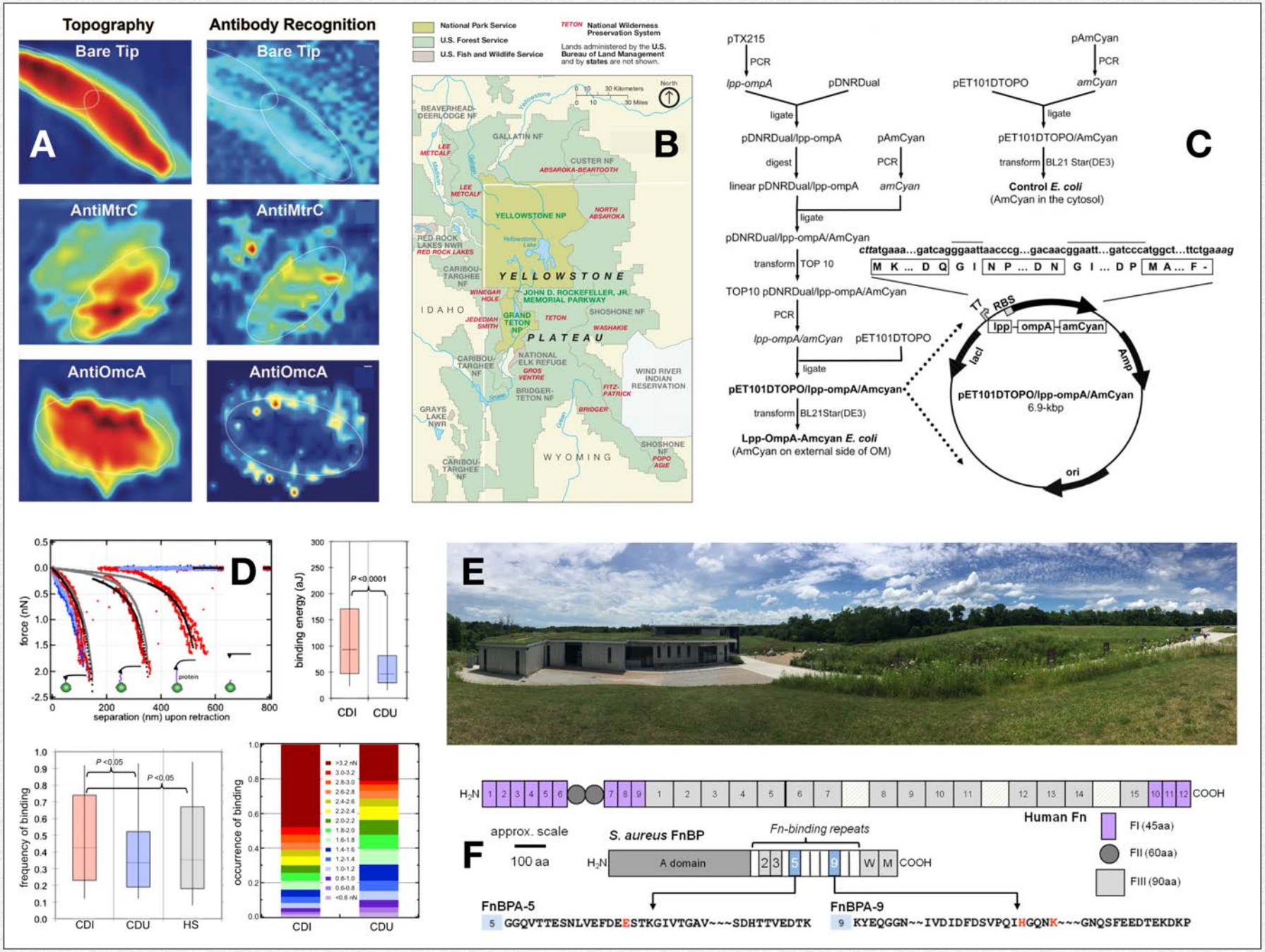

Table I. Individual bird banding in Glacier National Park from 2015-19.

Tag ID	Bird Type	Year Tagged	Sex	Wing Length (cm)	Mass (g)
021	Western Kingbird	2016	Female	8.8	92
088	Clark's Nutcracker	2017	Female	8.7	115
122	Common Swift	2019	Male	6.5	87
168	Western Jay	2015	Female	9.2	123
345	Mountain Bluebird	2018	Male	7.3	101
444	Downy Woodpecker	2017	Male	7.1	72

Birds were captured in July at the Logan Pass Visitor Center using the Brown-Smith flagged net system (Brown-Smith et al, 2012). To minimize stress, all birds were tagged, measured and released within 15 minutes of capture.

Table I. Tables are used to organize data and information into columns and rows. Tables are typically used to communicate large amounts of data to a reader in a systematic manner. Table font size should be easy for an audience to read when viewing from a distance of 2-3 feet (1 meter). Therefore, it is recommended that a minimum of 20-point font be used in tables.

Poster Presentation

5

A poster presentation consists of (1) the poster and (2) a person who presents the research to (3) an audience.

A presentation lasts 5-10 minutes.

The audience is typically 1-5 people at a time.

It is acceptable for the audience to ask the presenter questions during their presentation.

Poster Presentation

Characteristics Of A Poster Presentation

1. **Dress professionally and understand all parts of your poster.**
2. **Most poster presentations take place in a large room with dozens to hundreds of individual poster presentations occurring simultaneously.**
3. **A typical presentation lasts 5-10 minutes.**
4. **Typical audience size for an individual poster presentation will be 1-5 people.**
5. **It is acceptable for the audience to ask questions during a presentation.**
6. **The presenter should use figures and tables to communicate with the audience.**

Excellent Poster Presentations are Simple

The presenter is the scientist or engineer who conducted the research. The presenter is an expert in that particular field and should be confident (but not arrogant) when presenting the research to their audience. The presenter should understand everything that is in their poster (e.g., issue, topic, figures, tables, references). The presenter should relax, speak clearly, start with the introduction, move through the methods, results and end with the discussion section. The presenter should engage in conservation with the audience and answer their questions during the poster presentation. The presenter should not read word-for-word from a script, but rather they should follow a general progression through their poster (**Fig. 16**) that allows for active and organic discussion between them and the audience.

Tips for Giving a Poster Presentation

1. Practice your presentation several times before the poster event. Dress professionally. Your audience will be focused on your poster for 5-10 minutes so you don't have much time to capture their attention and tell your story. Engaging figures, maps, graphs will help capture their attention.

2. Focus most of your presentation on your figures and tables. Your audience will focus on figures, graphs, tables, maps. They rarely read the poster text. If they read any text at all, it

Figure 16. Parts of a Poster

THE OHIO STATE UNIVERSITY

Poster Heading

Increased Temperatures in the Bering Sea Area Cause Tufted Puffin Populations to Diminish

Poster Title

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ABSTRACT

Abstract

The Bering Sea area has been under close supervision after it has seen temperature fluctuations in recent years, most likely due to change in climate. Many organisms in the area changes dying in of climate change in the Bering Sea, the water and air temperatures were monitored, as well as organism populations. The diets of the tufted puffins were recorded, as well as the behavior of their primary prey. For tufted puffin populations, it was observed that many of the hatchlings weren't healthy enough to become fledglings before dying. Because their primary food source, the sand lance fish, prefer colder waters, the puffins were forced to feed their young less nutritious alternatives, causing the survive. Decreases in th the bottom of the food ch the tufted puffins, and ma starve to death. Because it is speculated that overall climate change is the cause of the increased temperature of the Bering Sea, there is not much that humans can do at this time besides continuing to research and monitor the conditions of the location

INTRODUCTION

Introduction

The Bering Sea, off the west coast of the United States, is an extremely important ecosystem, providing resources for "large populations of shellfish, marine birds and marine mammals.[1,6] The clim experienced "interde temperature fluctuati content.[8,11] A major food source for the tufted puffins in this area are the juvenile herring and sand lance.[5] Because puffins, like many other sea birds, spend the majority of their time near or in the water, "their population dynamics are logically tied to oceanic conditions.[3,4] Recently, water and air temperatures in the Bering Sea have risen again after a cold snap in 2010, and the new warmer water has caused a large drop in tufted puffins' major food supply, because of the decrease in large zooplankton, and many of young birds [illegible].[9] Contributing to the increased water peratures in the area is a "high-pressure system" cast the North Pacific.[10] Warming temperatures in this area have affects on sea ice, organism populations, and the large fishing industry present off the west coast of the United States.[10]

In-Text Citations

Materials & Methods

Cold Air T

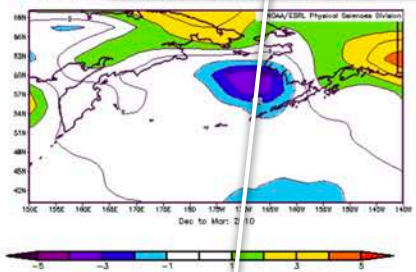

Fig. 5 Cold shift in air temperature in Bering Sea during 2010 before recent increased temperatures. Napp, J. (2010). The Bering Sea: Current status and recent events. National Oceanic and Atmospheric Association.[9]

METHODS & RESULTS

Because the population of tufted puffins in the Bering Sea area is only around 6,000, the recent death and recovery of about 250 of concerning for scientists in the as many as half of the entire y the warmer waters.[7,9] The air and water temperatures in the Bering Sea area have been monitored for years, and large fluctuations between extremely cold and extremely warm clim the current state of the Be scientists studying the ma of zooplankton at the bott number of surviving puffin hatchlings, the future of the tufted puffins in the Bering Sea is unknown, but scientists hope to do more research to understand the overall effects these warm temperatures have on the ecosystem.

Results

Current Increased Water Temperature off Coast of Alaska

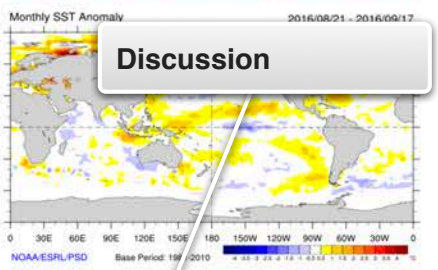

Fig. 7 Current temperatures in the Bering Sea during time of increased heat. Belles, J. (2016). The blob is back: Anomalous warmth returns to the North Pacific Ocean. The Weather Channel.[1,2]

DISCUSSION

Discussion

Because the climate in the Bering Sea area is continuously fluctuating and is due in part to worldwide temperature and climate changes, humans will have trouble directly improving the changes in the ecosystem. However, scientists are able to monitor the changes and provide continuous updates on the status of the Bering Sea climate and the organisms that inhabit it in order to prevent mass deaths of organisms in the future.

BIBLIOGRA

References

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2. Carr, A. (2016 Nov. 10). Warmer waters may be killing hundreds of puffins in Alaska, scientists say. *The Weather Channel*

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4. Grebmeier, J. M., Helle, J. H., Frey, K. E., McNutt, S. L., McLaughlin, F. A., Cooper, L. W., Moore, S. E., Overland, J. E., Carmack, E. C., Farley, E. V. (2006). A major ecosystem shift in the northern Bering Sea. *Science*, **311**(5766): 1461-1464.

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7. Kaufman, K. Tufted puffin, fratercula cirrhata. *National Audubon Society*. Retrieved Feb. 2017.

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9. Napp, J. (2010). The Bering Sea: Current status and recent events. *National Oceanic and Atmospheric Association*.

10. Welch, C. (2016 Nov. 8). Huge puffin die-off may be linked to hotter seas. *National Geographic*.

11. Yeo, S., Shim, T., Jhun, J., Kim, B., Kim, K., Yeh, S. (2014). Recent climate variation in the Bering and Chukchi Seas and its linkages to large-scale circulation in the Pacific. *Climate Dynamics*, **42**(9-10): 2423-2437.

Surface Temperature in Bering Sea Area from 2000-2005

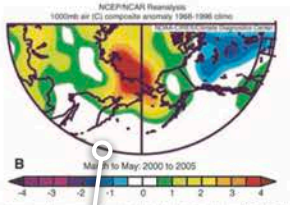


Fig. 1 Near-surface temperature anomaly near the Bering Sea during 2000-2005. Grebmeier, J. M., Helle, J. H., Frey, K. E., McNutt, S. L., McLaughlin, F. A., Cooper, L. W., Moore, S. E., Overland, J. E., Carmack, E. C., Farley, E. V. (2006). A major ecosystem shift in the northern Bering Sea.

Captions

Area Where Tufted Puffins are Found

Fig. 3 Tufted puffins are commonly found along the Northern Pacific coast, near Alaska. Tufted puffins feed mostly on fish, and their migratory habits are not largely studied. Kaufman, K. Tufted puffin, fratercula cirrhata. National Audubon Society. Retrieved Feb. 2017.[7]

1,000 puffins per km²

2,000 puffins per km²

Multiple Dead Puffins Discovered

Fig. 4 Many dead puffins were found on Bering Sea shore in late 2016, with rising ocean temperatures suspected to be the underlying cause. Welch, C. (2016 Nov. 8). Huge puffin die-off may be linked to hotter seas. National Geographic.[10]

Figure

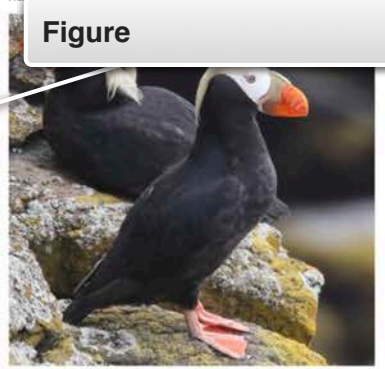
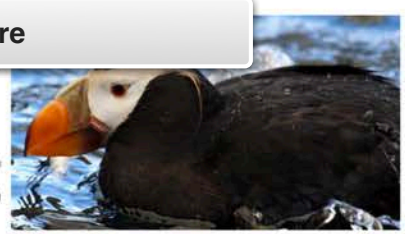


Fig. 6 The tufted puffin (fratercula cirrhata). Many of the puffins found on the shore starved to death because of lack of food supply. Carr, A. (2016 Nov. 10). Warmer waters may be killing hundreds of puffins in Alaska, scientists say.[7]

Figure



waters usually mean less zoo plankton for these birds to eat. Carr, A. (2016 Nov. 10). Warmer waters may be killing hundreds of puffins in Alaska, scientists say. The Weather Channel [1]

will likely be the abstract and figure captions so a presenter really focus on figures and tables when they prepare for their poster presentation.

3. Speak clearly and know your topic. Remember you are the expert so you need to understand all parts of your poster.

4. Presenters should start their presentation (**Fig. 17**) by introducing themself and moving onto the Title and Introduction sections. Describe the issue and use figures to help explain the story. Use maps to show the study area, use photographs of the organism or pollutant or issue, use graphs and tables to show patterns (e.g., population increased over past 5 years) focus on important points. Flow from one figure to the next, ending with the discussion and conclusion sections. The presenter should point to the poster when they are talking about a specific figure, and use words and their hands to help explain each part of the poster.

5. Allow your audience to participate, allow them to ask questions throughout your presentation (**Fig. 18**). Always be respectful of your audience. Always try to answer their questions. If you don't know the answer, the best thing to say is "I don't know the answer but I can point to another study here in my references section where other scientists are working on this very question." Engage your audience and show them where to find additional work (e.g., journal articles, names of scientists) about the topic.

Figure 17. Poster Presentation.

Figure 17. The poster presenter (left) is communicating with his audience (right) in an oral and visual manner.

6. Avoid saying things like "stuff" and "things" and other general phrases like "this work was great". Give specifics because this demonstrates to the audience that you understand your topic. Use the vocabulary words that you learned and explain these to the audience. For example, rather than say "This work was great for orangutans." You could say: "This work was great because it was the first time that we observed orangutan feeding behavior in the wild and it allowed us to determine that female orangutans need 5,500 calories per day during their breeding season. Those females that ob-

tained 5,500 calories per day were twice as likely to give birth."

7. Be prepared for a lively and dynamic event (**Fig. 19**). Poster events typically consist of dozens or hundreds of individual poster presentations occurring simultaneously in the same room. These events are typically very loud and energetic. Food and beverages are typically provided at the event.

8. Be flexible. The audience will walk around to view as many posters as possible, stopping occasionally to view a poster and talk to a poster presenter about their research. Some people may talk with the presenter for a few seconds, others may spend 15-20 minutes talking with a poster presenter. Presenter-audience interactions will be rather informal and dynamic.

9. Read the poster guide and map prior to attending the poster event. A poster program guide and poster map will be published ahead of the event so that the audience knows where to find each poster and so that the presenter knows where to set up their poster.

10. Wear comfortable shoes. Posters are typically displayed on an easel and the presenter stands by their poster during

Figure 18. Two-Way Communication is Key to a Successful Poster Event.

Figure 18. The presenter (left) and audience (right) are talking with one another.

Figure 19. Poster Event at The Ohio State University.

Figure 19. This event consisted of approximately 150 individual posters, presenters and audience. Posters are numbered and presentations are occurring simultaneously.

the entire event, which can last up to 2 hours.

Abstract

A single paragraph, typically 200-400 words in length, that appears at the very beginning of a poster. It is a summary of the research presented in the poster and consists of four parts: Introduction, Materials & Methods, Results and Discussion. Each part is typically 2-4 sentences long. An abstract is strictly text, it contains no figures and no tables.

Related Glossary Terms

Discussion, Introduction, Materials & Methods, Results

Index Find Term

Acknowledgements

The section of a poster that typically appears at the very end of a poster. The name of funding agencies who provided financial support for the research will be listed in this section. Authors also use this section to thank people who contributed to the research but did not provide substantial contribution to the work that they should appear as a co-author on the poster.

Related Glossary Terms

Drag related terms here

Index Find Term

Authors

Scientist(s) who designed, planned and conducted the research and wrote the poster. The scientist who made the most significant contribution to the research is listed first in the author list, the scientist who contributed the 2nd most is listed second in the author list and so on.

Related Glossary Terms

Drag related terms here

Index Find Term

Bibliography

Also know as References section of a poster. The section of a poster where scholarly publications (i.e., sources of information), which are referred to in the poster are listed. By citing other peoples' work, the author is (1) giving proper credit to the work of other scientists, (2) justifying why the research is being conducted, (3) providing context for the research, (4) demonstrating the significance of the work and (5) providing additional knowledge and understanding for the research. The Bibliography section typically include information that helps the reader find important information such as; author names, year published, title of article, name of journal, volume number and page numbers.

Related Glossary Terms

References

Index Find Term

Citation

A formal reference to a published work or source of information. A citation is included at the end of a sentence to indicates the source of the information. Citations are listed by number or author name, year published.

For example:

1. Polar bear cubs were 25% larger when fed a high-protein diet compared to high-sugar diet.[1]

2. Polar bear cubs were 25% larger when fed a high-protein diet compared to high-sugar diet (Jones and Smith, 2018).

The “1” and “Jones and Smith, 2018” both refer to the same journal article: E.J. Jones and W. A. Smith (2018), Journal of Natural Science, Vol. 53, Issue 12, pages 36-45. Both types of in-text citations are acceptable for use in posters, with people typically choosing superscript numbers to save space.

Related Glossary Terms

Primary Source, References, Secondary Source

Index Find Term

Data

Information, measurements, numbers, observations collected as part of an experiment. The experiment can be conducted in a laboratory setting or in the field. Specific instruments, methods and techniques are used to collect data. Data is typically presented to an audience in the form of a graph or table.

Related Glossary Terms

Figure, Graph, Results, Table

Index Find Term

Diagram

Type of figures that uses a schematic drawing to show how something functions, flows or is structured.

Related Glossary Terms

Figure, Map

Index Find Term

Discussion

The section of a poster that is dedicated to interpreting the results of the research. The Results section and Discussion sections are often combined in a poster to save space and make it easier for the reader to understand the research. The Discussion section is used to (1) describe what the results mean, (2) compare results to other studies, (3) characterize the significance of the results, (4) report the limitations of the research and (5) suggest future research.

Related Glossary Terms

Abstract

Index Find Term

Figure

An image, chart, data plot, graph, map, diagram, schematic, photograph that is used to communicate information and data. Many readers will only look at poster figures rather than reading the main text. Therefore, it is very important that figures are engaging and easy to read and understand. A figure should be used in a poster to communicate the most significant results of the research. A descriptive caption that explains the data should also accompany each figure.

Related Glossary Terms

Data, Diagram, Graph, Map, Results

Index Find Term

Graph

A type of figure that shows the relationship between two varying quantities. Graphs can be bar charts, line plots or scatter plots.

Related Glossary Terms

Data, Figure, Results

Index Find Term

Introduction

The section of a poster that appears directly after the Abstract and is used to introduce the reader to the topic. It provide all the necessary information needed to understand the research, topic or issue. It describes the importance of the research, especially in context to previous work that has been conducted in this area. It helps to set the stage for the research described in the poster and provides clear objectives for why the work was conducted.

Related Glossary Terms

Abstract

Index Find Term

Journal

A periodical publication containing many articles that describe original research conducted by scientists and engineers. Journals publish several issues throughout the year that contain the most recent research, data and information about a topic. Journals are used by scientists and engineers as the primary means to disseminate research findings. Science journals are typically published by professional societies that specialize in particular disciplines. There are thousands of different scientific journals.

Articles are evaluated using a peer review process prior to publication. Only those articles that successfully make it through the peer-review process are published. Rejected articles are not published and therefore not seen or read by the public. High-impact journals typically accept a small fraction (e.g., 10-25%) of all articles for publication. The remaining articles do not make it through the peer-review process and are rejected.

Related Glossary Terms

Journal Article, Peer Review, Primary Source

Index Find Term

Journal Article

A piece of writing that is published in a journal, describes original research and is authored by the scientists and engineers who performed the work and conducted the experiments. Because of this, journal articles are referred to as primary sources of information. and published by professional journals. Journal articles have gone through a rigorous peer-review process prior to being published. Only those articles that successfully make it through the peer-review process are published. Rejected articles are not published and therefore not seen or read by the public.

Journals publish several issues throughout the year that contain the most recent research, data and information about a topic. High-impact journals typically accept a small fraction (e.g., 10-25%) of all articles for publication. The remaining articles (e.g., 75-90%) do not make it through the peer-review process and are rejected.

Related Glossary Terms

Journal, Peer Review, Primary Source

Index Find Term

Chapter 3 - Primary Sources

Keynote

A software program developed by Apple to create presentations as well as slides, figures, graphs, diagrams, flow charts, images, maps, etc.

Related Glossary Terms

PowerPoint

Index Find Term

Map

Type of figure that shows an area of land, water, cites, forests, physical characteristics, etc. A map typically contains scale bars and cardinal directions (i.e., north, south, east, west) to help orient the reader.

Related Glossary Terms

Diagram, Figure

Index Find Term

Materials & Methods

The section of a poster that provides details about how the research was conducted. Authors use this section to describe methods, techniques, equipment and instrumentation that was used for the research. Materials, chemicals, compounds, organisms, molecules, minerals, and samples that were used in the work are also described here. If the research was conducted at a specific location (e.g., institution, field site) or time of year then these details are provided here as well. The information provided in the Materials and Methods sections allows other scientists to reproduce the work presented in the poster.

Related Glossary Terms

Abstract

Index Find Term

Newspaper

A publication that is printed daily or weekly and contains stories about current events, features, opinions and advertisements. Newspapers analyze and interpret the research that was presented in a primary source. Newspapers are considered secondary sources of information because they are published after a journal article has been published. Compared to journal articles, newspapers are typically easier for an audience to read and understand because much of the scientific jargon has been replaced or removed. Newspapers are reviewed by editors prior to publication. Newspaper articles do not go through a peer review process prior to publication.

Related Glossary Terms

Secondary Source

Index Find Term

Patent

Document of intellectual property granted by a government that describes a discovery, invention, process, machine, instrument, manufacture, matter or material,

Related Glossary Terms

Primary Source

Index Find Term

Peer Review

A research article that has been published in a journal went through a rigorous review process where experts (i.e., peer scientists) evaluated the article and deemed the research worthy of publication. This process is referred to as scientific peer review. It is done to ensure that the research is original, that experiments are conducted in an appropriate manner, that data support results and conclusions and that articles meets quality standards set forth by the publisher. Only those articles that successfully pass through the peer review process are published and read by the public. Articles that don't make it through the peer review process are rejected, not published and therefore are never read by the public.

Many journals, such as high-impact journals, follow a rigorous peer review process that results in rejection rates greater than 75%. Those articles that successfully navigate the peer review process (e.g., the remaining 25%) are published by the journal, read by the public and are referred to as primary sources.

Related Glossary Terms

Journal, Journal Article, Primary Source

Index Find Term

Poster Printing

Posters are very large (e.g., 48-inches x 36-inches) and need to be printed at a print shop using a specialized type of printer such as a plotter or wide-format conventional printer. Universities, libraries, FedEx, UPS all have printing services that, for a price, can be used to print a large-format poster. Prices vary from $50-$150 and turnaround times vary from 1 hour to 24 hours.

Ohio State University has several locations where students can print a large-format poster: https://u.osu.edu/chow.57/2013/11/08/osuposter/

Related Glossary Terms

PowerPoint

Index Find Term

PowerPoint

A software program developed by Microsoft to create presentations. Many people use Microsoft PowerPoint to create and print a large-format poster. PowerPoint can also be used to create figures, graphs, diagrams, flow charts, images, maps, etc.

Related Glossary Terms

Keynote, Poster Printing

Index Find Term

Primary Source

A journal article written by scientists and engineers and published in a journal. Journal articles are a full description of original experiments and research. Journal articles are written by the scientists and engineers who conducted the work. Journal articles contain an abstract, introduction, materials & methods, results, discussion and references. Journal articles are only published after they have successfully passed through a peer-review process. Rejected articles are not published and therefore the public never reads the article.

Patents and technical reports published by government agencies are also considered primary sources.

Related Glossary Terms

Citation, Journal, Journal Article, Patent, Peer Review, References, Technical Report

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Index Find Term

References

The section of a poster where scholarly publications (i.e., sources of information), which are referred to in the poster are listed. Also known as bibliography. By citing other peoples' work, the author is (1) giving proper credit to the work of other scientists, (2) justifying why the research is being conducted, (3) providing context for the research, (4) demonstrating the significance of the work and (5) providing additional knowledge and understanding for the research. The References section typically include information that helps the reader find important information such as; author names, year published, title of article, name of journal, volume number and page numbers.

Related Glossary Terms

Bibliography, Citation, Primary Source, Secondary Source

Index Find Term

Results

The part of the poster where data, findings and information that was discovered as part of the research is provided. Figures and tables are often used in the results section to communicate these data, findings and information to the reader.

Related Glossary Terms

Abstract, Data, Figure, Graph, Table

Index Find Term

Secondary Source

Article or video written or produced by someone who did not participate in the research. Examples are books, documentaries, films, government websites, interviews, magazines, newspapers, news programs, podcasts and videos. Secondary sources report on and interpret results that have been presented in primary sources. Secondary sources generally have not been peer reviewed, however, they have been reviewed by editors, writers and producers prior to publication because they want to maintain a high degree of integrity with their work and publication

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Related Glossary Terms

Citation, Newspaper, References

Index Find Term

Table

A way to organize data into columns and rows to effectively present large amounts of data to an audience. Many readers will only look at poster tables rather than reading the main text. Therefore, a table should be clear, easy to read, contain legible font type and sizes (e.g., 20-point font size are larger), have sufficient space between rows and columns, contain units of measurement, and have a legend or caption that explains the data.

Related Glossary Terms

Data, Results

Index Find Term

Technical Report

Document that describes scientific findings, progress of projects and the results of scientific research. It is an official document that provides a summary of research conducted over an extended period of time. Technical reports are published by government agencies, universities and corporations.

Technical reports do not necessarily go through a peer-review process prior to publication. If the report was written by the scientists who conducted the research, then it can be considered a primary source of information.

Related Glossary Terms

Primary Source

Index Find Term

Title

A brief headline (typically 5-15 words) that appears at the very top of a poster and functions to provide a descriptive overview of the poster. It is used to inform the reader what the poster is about.

Related Glossary Terms

Drag related terms here

Index Find Term