RELIABLE SOURCES, DATA VALIDITY, AND HOW TO READ A SCIENTIFIC JOURNAL ARTICLE

Objectives

- Distinguish between science and pseudoscience.
- Determine if a source is reliable.
- Explain the peer-review process.
- Evaluate a source for bias.
- Read scientific journal articles.
- Determine if a data set is valid.

Introduction

The Coronavirus (aka COVID-19 and SARS-CoV-2) has been a major portion our lives since early 2020. The study of this virus falls in to the realm of biochemistry. By studying the coronavirus in this class, we are able to apply some of the concepts we are learning about soap, DNA, RNA, replication, and mutation to a real-world situation. We also get a glimpse of how scientists are using the scientific method to study this virus, learn how it spreads, how we can limit the spread, and eventually develop a vaccine.

Science is the systematic process by which we learn about the world. Scientists are basically professional students and explorers. They are constantly investigating the world around us to learn more about the how and why it works as it does.

When you first started learning something, did you instantly know everything about it? At your first piano lesson, were you able to play Ragtime by Scott Joplin? In the first day of Spanish, were you able to speak and read fluently to your classmates and teacher? When you first got behind the wheel of a car, where you able to brake without jerking, shift smoothly, and merge on and off the interstate without concern?

The answer to all of these questions is no. You needed time to learn the keys and the notes on the piano, to learn vocabulary and how to conjugate verbs, and how to coordinate your hand, eye and foot to smoothly maneuver the car and navigate traffic.

This is what scientists do on a daily basis. They learn, share the knowledge they have obtained, and they continue to study so they can learn more. They work with what they know, understanding that tomorrow, they will know more and that may change their working hypotheses/theories about a concept. Scientists are on the frontier of what we know. This is the difference between a scientist and a Spanish teacher – the teacher already knows the vocabulary and how to conjugate the verbs. When they teach their classes, they are regurgitating what they already know. Scientists are not only speaking the language, but also expanding the vocabulary and trying to teach others what they know as they learn it. They are on the edge of knowledge.

Most of the science we learn in school and see in the world around us is tried and true. It's already gone through the process of rigorous testing and investigation. We didn't

witness the learning, changing, and uncertainty that went along with that process. Coronavirus is a topic on the edge of the science we know. It is still being studied and we are learning new things about it every day. This is why the information changes so quickly. It's not that science doesn't know what it's doing but rather that it is constantly learning new details and getting a better picture of Coronavirus and making adjustments to hypotheses and theories as it goes. Humans just aren't used to this rapid change in information and behavior. We like certainty and we don't have all the information yet about coronavirus to be certain in the situation.

There is a LOT of information available on the coronavirus, some of this information is correct and reliable while other information is incorrect, unreliable, and spreads dangerous misinformation about the coronavirus, how it is spread, and how to protect yourself and others. It is important to be able to determine true science from pseudoscience, fact from fiction, and reliable sources form unreliable ones.

Today, we are going to learn what makes a study scientific, the difference between science and pseudoscience, identify bias, and if a source is credible or not. I have included some links to resources in the introduction for this activity. It is highly recommended that you access these outside sources to obtain a better understanding of the concepts discussed in this activity.

Science vs Pseudoscience

Science is the systematic process by which we learn about the world. The system that scientists use to study the world is the scientific method. The goal is to examine an hypothesis. The results of an experiment determine if a hypothesis is confirmed or rejected. A scientist will work to design a good experiment that tests their hypothesis without bias or preference regarding the experimental results. Science peruses facts, truth, and reproducible results. Science starts with a question and works towards the true answer. It involves multiple experts to review the data, repeat the experiments, and determine if the data is valid before publication. Science is not conducted in a bubble and can be examined by any other expert.

Pseudoscience searches for a predefined answer. This may start with a hypothesis; however, only data that supports the hypothesis will be considered. Any evidence against the hypothesis is ignored or hidden. Sometimes, pseudoscience starts with an outcome and works backwards to create the hypothesis. This is the scientific method in reverse and not a valid use of the scientific method. Pseudoscience does not involve the search for truth but rather proving an agenda using whatever possible. Data is not reproducible, peer reviewed, or necessarily true. Research is not open for the scientific community to evaluate before publication. Often these reviews are conducted in a small bubble of like-minded people, if a review of the data is conducted at all. Table 1.0 outlines specific differences between science and pseudoscience.

Table 1.0

Comparing Science and Pseudoscience

Science	Pseudoscience
1. Uses careful observation and experimentation to confirm or reject a hypothesis. Evidence against theories and laws are searched for and studied closely.	1. Starts with a hypothesis, looks only for evidence to support it. Little or no experimentation. Conflicting evidence is ignored, excused, or hidden. The original idea is never abandoned, whatever the evidence.
2. Based on well-established, repeating patterns and regularities in nature.	2. Focuses, without skepticism, on alleged exceptions, errors, anomalies, and strange events.
3. Reproducible results are required of experiments. In case of failure, no excuses are acceptable.	3. Results cannot be reproduced or verified. Excuses are freely invented to explain the failure of any scientific test.
4. Personal stories or testimonials are not accepted as evidence.	4. Personal stories or testimonials are relied upon for evidence.
5. Consistent and interconnected; one part cannot be changed without affecting the whole.	5. Inconsistent and not interconnected; any part can be arbitrarily changed in any way without affecting other parts.
6. Argues from scientific knowledge and from the results of experiments.	6. Argues from ignorance. The lack of a scientific explanation is used to support ideas.
7. Uses vocabulary that is well defined and is in wide usage by co-workers.	7. Uses specially invented terms that are vague and applied only to one specific area.
8. Convinces by appeal to evidence, by arguments based on logical and/or mathematical reasoning.	8. Attempts to persuade by appeal to emotions, faith, sentiment, or distrust of established fact.
9. Peer review. Literature written for fellow scientists who are specialists and experts.	9. No peer review. Literature written for the general public without checks or verification.
10. Progresses; as time goes on, more and more is learned.	10. No progress; nothing new is learned as time passes. There is only a succession of fads.

*Data table copied from https://physics.weber.edu/carroll/honors/pseudoscience.htm

Determining if a Source is Credible / Identifying Bias

It is important that we obtain information from reliable sources when researching a topic. Sources should meet the guidelines for identifying trusted sources. , which help determine if a source is reliable and reliable. A reliable source can be a peer-reviewed source, meaning that the article has been reviewed by experts in the field to ensure the information it communicates is accurate and worth publishing. Peer-reviewed sources are most commonly found in academic and scholarly journals such as *The New England Journal of Medicine*, *Science Magazine*, and *The Journal of the American Chemical Society.* Figure 1.0 provides a summary of the peer-review process.

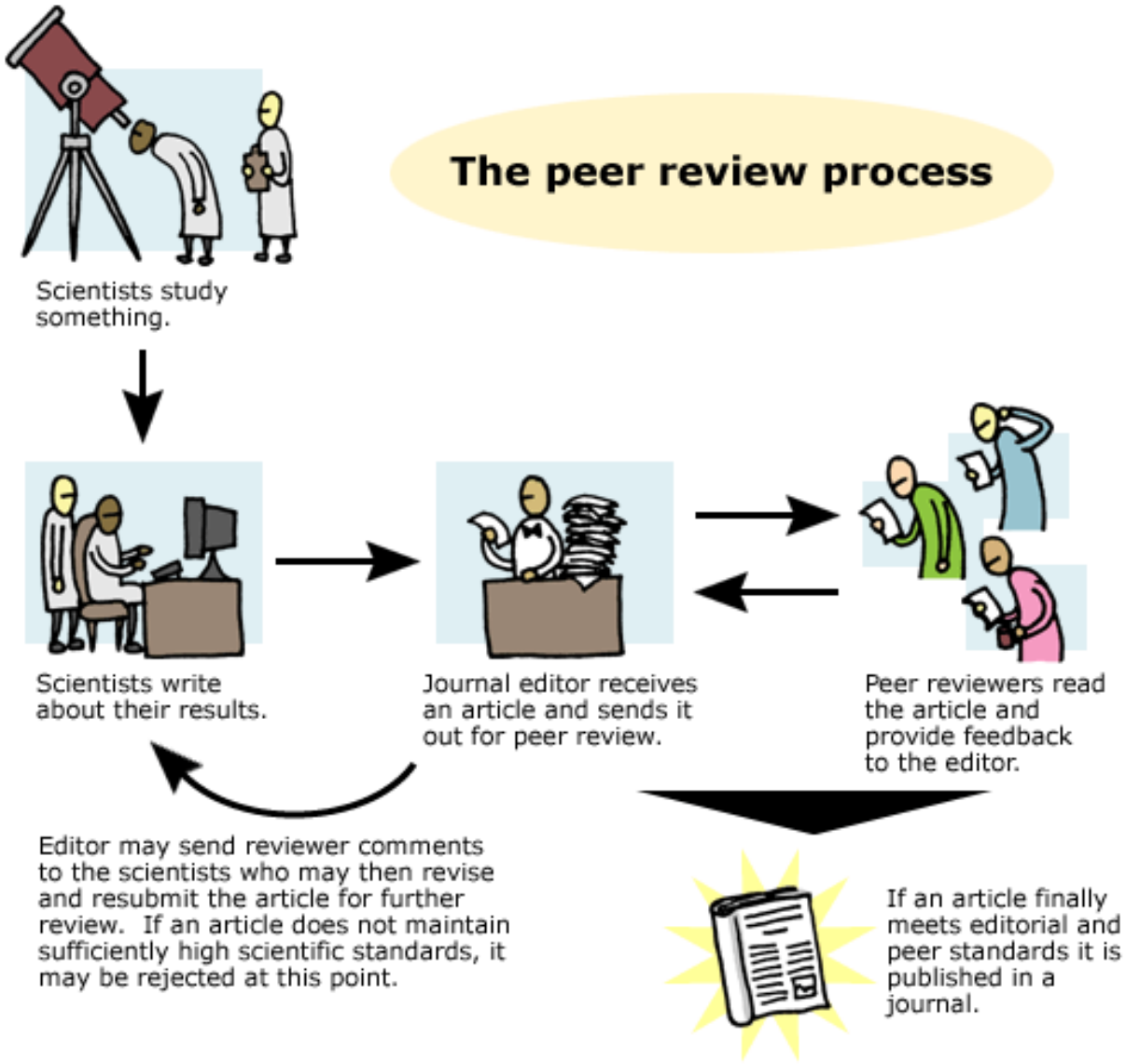

Figure 1.0: The Peer Review Process.
Obtained from https://undsci.berkeley.edu/article/howscienceworks_16

For additional information about determining if online information is reliable, please check out the entire Crash Course series on Navigating Digital Information. They provide a very comprehensive look at how to evaluate sources. The Indiana University Library also provides some great information on how to complete a research project and evaluate sources for reliability.

Bias and Uncertainty

Bias refers to something being off center, unbalanced, leaning to one side or another, or favoring one perspective over another. The bias we hear most about today is Media Bias, the leaning of a news media source towards one political party or another. Since a lot of science is communicated to the general public via news media, it is important to be aware of this and account for it when reading newspapers, listening to podcasts, and watching news videos on the TV or internet. The chart below will help you assess Media Bias when determining if a source is credible and reliable.

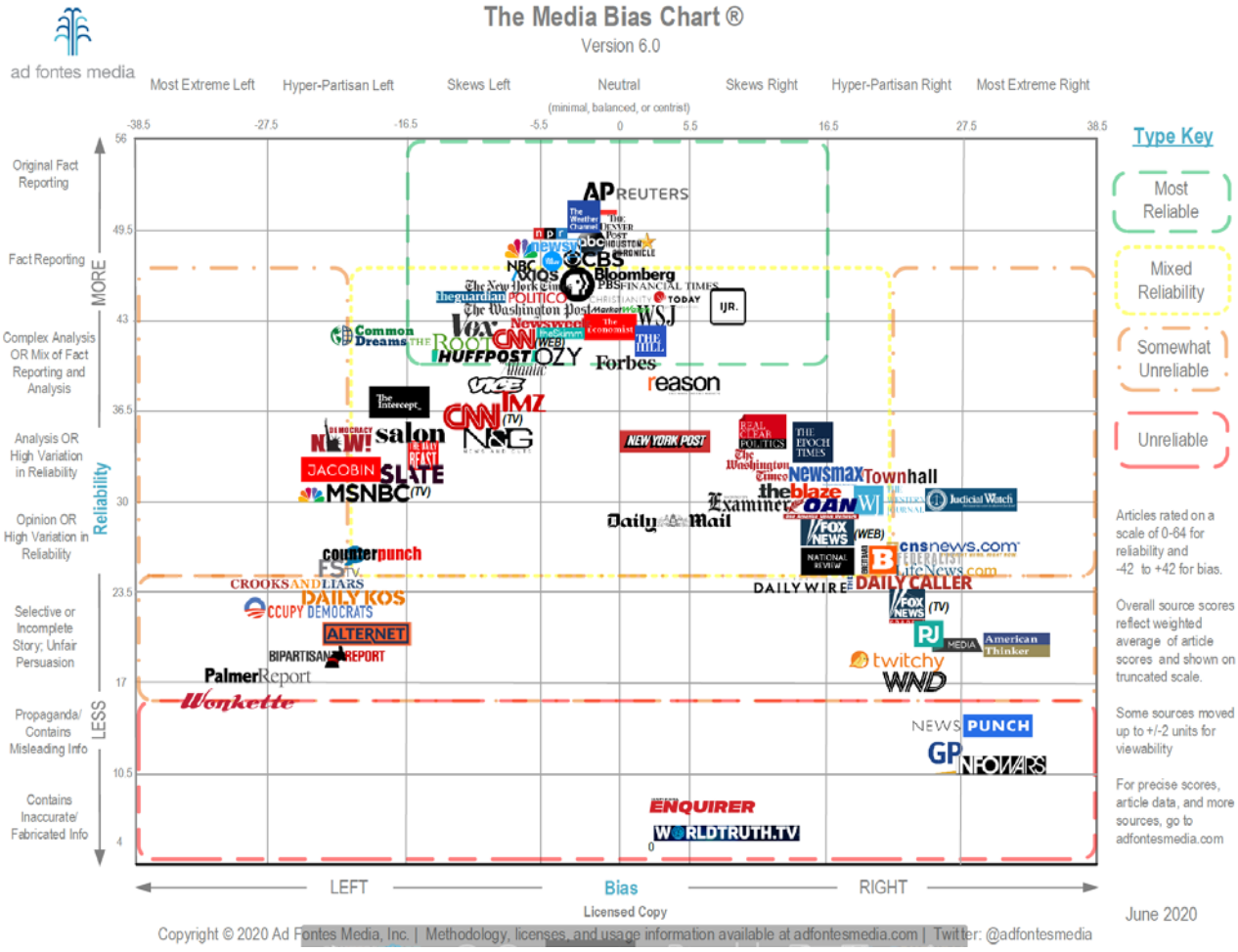

Figure 2.0: Media Bias Chart
Obtained from https://www.adfontesmedia.com/ .

In the scientific literature, bias refers to influences that may impact the conclusion of research findings. This can include systematic error, flaws in the study design, deviation in the interpreted outcome of a study because of flawed data, etc. This is bias that does not come from a sense of predudice, unlike Media Bias. There are other biases that come into play regarding research publication. Proper equipment calibration, conducting multiple trials, peer review, using controls, and conducting double-blind studies are designed to reduce the chance of bias, but it can still happen. This is why it is important to always be critical of what we read to ensure it makes logical sense.

"Uncertainty is the quantitative estimation of error present in data; all measurements contain some uncertainty generated through systematic error and/or random error." (Carpi 2021) This doesn't mean that scientists are not certain of their data, rather it specifies the degree to which they are confident in their data. The lower the uncertainty, the higher the confidence. There is uncertainty in everything we do, scientific or not. Scientists choose to recognize and measure this to add validity to their data meaning. Ways to acknowledge and correct for uncertainty in scientific research is discussing errors encountered during the experiment, minimizing systematic or random errors, completing a statistical analaysis of the data (mode, median, mean, range, standard deviation, etc.), utlizing significant figures when taking measurments and completing calculations, etc.

Resources for Finding Journal Articles

There are many resources for finding peer-reviewed scientific articles. Below are a few that are free for you to access.

- *Riverland Library Services*
  Riverland has a data base of journal articles that can be found at https://www.riverland.edu/student-services/library/. Additional information on how to use the library resources offered by Riverland can be found at https://www.riverland.edu/student-services/library/library-video-guides/.
- *Google Scholar*
  Google Scholar is a free database of journal articles and other resources provided by Google. Some of these articles are peer reviewed, others are not, so you need to verify this more carefully with Google Scholar. Additionally, the full text is not always availble for each document. To access Google Scholar, go to https://scholar.google.com/.
- *PLOS*

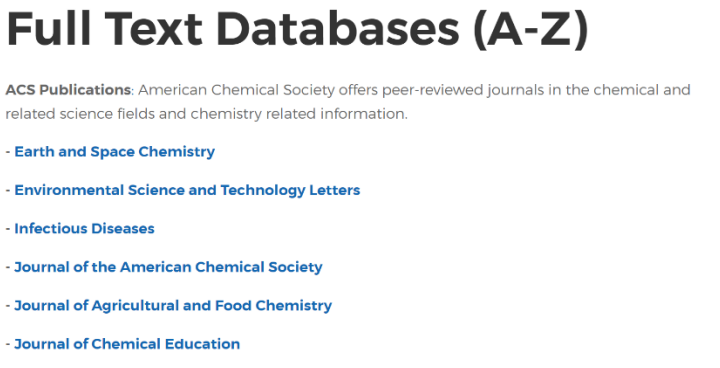

Figure 3.0: Full-text scientific journals available online through the Riverland Library.

PLOS is a free, open-source, peer reviewed scientific journal started in 2001. They provide many publications across all areas of science and medicine. PLOS publications can be accessed at www.plos.org.

- *Directory of Open Access Journals* (DOAJ)
  The DOAJ is a community-curated online journal and article database that provides high-quality, peer-reviewed journals in 80 languages. DOAJ can be accessed at https://doaj.org/.
- *Searching specific journal websites*
  You can also search specific scientific journals for articles. A few are specifically listed at the top of the A-Z full text database offered through the Riverland Library (see Figure 3.0).
  A few other specific scientific journals can be found at the following websites:
  - The American Chemical Society - www.acs.org
  - C&EN - https://cen-acs-org.rvlproxy.mnpals.net/
  - Science Magazine - www.sciencemag.org

Resources for Properly Citing Sources

It is important to properly cite your sources so those who read your work know where you obtained your information. You will be required to cite your sources on assignmentsin this course. Below are some websites that can help you with citing sources in MLA or APA formats.

- University of Auckland https://www.cite.auckland.ac.nz/index.html
- OWL Purdue (Purdue Online Writing Lab) https://owl.purdue.edu/owl/purdue_owl.html
- Mavscholar – MSU-Mankato https://library.mnsu.edu/

References

Ad Fonts Media. (2021). https://www.adfontesmedia.com/

Biology Online. (2021). *Bias*. Biology Online. https://www.biologyonline.com/dictionary/bias

Carpi, A, Egger, A. *Uncertainty, Error, and Confidence. Visionlearning Vol. POS-1 (3), 2008. Accessed at* https://www.visionlearning.com/en/library/Process-of-Science/49/Uncertainty-Error-and-Confidence/157

Carpi, A, Egger, A, Kuldell, N. *Peer Review in Scientific Publishing.* Visionlearning Vol. POS-2 (2), 2009. Accessed at https://www.visionlearning.com/en/library/Process-of-Science/49/Peer-Review-in-Scientific-Publishing/159

Carpi, A, Egger, A, Kuldell, N. *Understanding Scientific Journals and Articles*. Visionlearning Vol. POS-1 (9), 2008. Accessed at https://www.visionlearning.com/en/library/Process-of-Science/49/Understanding-Scientific-Journals-and-Articles/158

Carroll, B. (2014) *Science and Psudeoscience*. Honors PS1500 Physics in the Plays of Tom Stoppard. https://physics.weber.edu/carroll/honors/pseudoscience.htm

Coker, R. (2001). *Distinguishing Science and Pseudoscience.* Quackwatch. https://quackwatch.org/related/pseudo/

Education Alberta. (2018). *1.5 Evaluating Resources.* Education Alberta. https://openeducationalberta.ca/libraryskills200/chapter/evaluating-resources/

Egger, A, Capri, A. *"Utilizing the Scientific Literature" Visionlearning Vol. POS-2 (7), 2009. Accessed at* https://www.visionlearning.com/en/library/Process-of-Science/49/Utilizing-the-Scientific-Literature/173

IUPUI. (2021). *Introduction to Library Research.* IUPUI. https://iupui.libguides.com/c.php?g=260416&p=1738857

Stanford University. (2021). *Science and Pseudo-Science*. Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/pseudo-science/

University of Georgia. (2021). *Finding Reliable Sources*. University Library University of Georgia. https://guides.libs.uga.edu/c.php?g=571070&p=3936511

Assignment

Once you have reviewed the information provided in the introduction and linked resources:

- Read the article provided on Brightspace titled *Ten simple rules for reading a scientific paper.*
- Read the article titled *Understanding Scientific Journals and Articles* (click link to access article).
- Read the article titled *Utilizing the Scientific Literature* (click link to access article).
- Read the article provided on Brightspace titled *Our lakes and rivers are getting saltier.*
- Answer the questions on the following pages.