# Resisting Scientific Misinformation

## A CURRICULUM UNIT FOR GRADES 6-12
## TEACHER GUIDE


BY ANDY ZUCKER
& PENNY NOYCE


# Resisting Scientific Misinformation

## A Curriculum Unit for Grades 6-12

## Teacher Guide

by
Andy Zucker and Penny Noyce

December 2018

Contents

## Introduction

Scientific misinformation has become so common that, as an editorial in *The Science Teacher* observed, "evidence-based reasoning seems under assault." It is of course *necessary* but it is no longer *sufficient* to teach accurate scientific information; in addition, science teachers should help students use critical thinking to examine claims they see, hear, or read that seem to be based on science but sometimes are not.

The internet continues to grow as Americans' primary source for science news and information (NSB, 2018), but online media offer significant amounts of misinformation as well as knowledge. "Climate change is a hoax," "Next month Mars will look almost as large as the full moon," "Babies who listen to our recordings develop higher IQs," etc. More than ever before, students need to be able to judge the quality of information they encounter, and understand which sources of scientific information are trustworthy and why.

Fortunately, social science research has identified experimentally tested methods to help students resist the proliferation of scientific misinformation, to some extent "inoculating" them. The following five lessons for science students in grades 6-12 are based on research. Each lesson is designed for a 45-minute class period. We hope you and your students find them interesting and useful.

- In the first lesson, students watch a 30-second video advertisement that was later determined by the Federal Trade Commission to be false and misleading. Students identify ways that advertising can be appealing and ways it can be misleading, and they create a misleading advertisement seemingly based on science.
- Lesson Two again focuses on advertising, and also on a recurring technique intended to mislead people, the argument that "the science is uncertain." This tactic was used, for example, by tobacco companies trying to persuade the public that smoking was safe. Students investigate a number of supposedly scientific claims, some true and others false.
- Lesson Three helps students identify appropriate questions to ask about dubious scientific claims in order to help decide whether they are credible. The lesson identifies questions similar to those used to investigate "fake news" in fields outside science. Students consider which sources of information are trustworthy and why.
- In Lessons Four and Five (note that Lesson Five is optional), students learn more about the scientific process, how scientists develop confidence that their conclusions are correct, and the role of scientific and professional organizations in synthesizing and communicating research findings. Students do research about how to help develop babies' minds—including whether certain widely promoted products actually boost infants' IQ—and write a note summarizing their findings.

The lessons incorporate brief narrated videos as well as many activities for students. These materials are available online, free of charge. Video files can be downloaded by teachers ahead of time, so an internet connection is not required during class. Note that Lessons 2, 3, and 4

assume students will be able to use computer devices in the classroom to access the internet. Teachers may need their IT department staff to unblock certain websites (e.g., the World Health Organization site is blocked in some schools).

These lessons have been used successfully in classrooms at multiple grade levels, and students enjoyed them. However, as a teacher, you know your students better than we do. Feel free to revise the lessons so they work as well as possible for the particular young people you teach. Several of the appendices include additional ideas to supplement the lessons, or to offer alternative topics to those included in the lessons. And if possible, send us feedback!

### When to Use this Unit

In the past little attention has been paid to teaching students how to judge the quality of what seems to be science-based information they encounter in media. As a result, use of this unit can benefit all students in grades 6-12, in any science class. Having said that, there are advantages to using the unit in middle school because teachers may have more flexibility and because the topic is important to and ought not to wait until students are in high school. The section immediately below identifies learning standards and goals with which the unit is aligned.

Claims provided in the unit, both true and false, are drawn from various disciplines, including biology, physics, health, and earth science. As a result, this unit fits well into many disciplinary courses, as well as General Science classes. If they wish, teachers of specialized science classes can add more examples drawn from a specific discipline.

### Standards and Learning Goals

This unit of study aims to promote students' critical thinking skills, and is aligned with various national education standards. For example, the **Common Core State Standards** include:

> CCSS.ELA-LITERACY.SL.7.2 Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.
>
> CCSS.ELA-LITERACY.SL.8.2 Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
>
> CCSS.ELA-LITERACY.SL.9-10.3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.
>
> CCSS.ELA-LITERACY.SL.11-12.3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

The unit is also well aligned with the **Next Generation Science Standards** (NGSS), which include the following three science "practices":

6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

NGSS also focuses on understanding the nature of science, for example by having students form "adequate, evidence-based explanations" of scientific phenomena. Both the NGSS and the National Science Teachers Association (NSTA) suggest that teachers use a "claim, evidence, reasoning" approach to science education. In this unit, students learn to use evidence and disciplined reasoning to accept or reject scientific claims.

Specific learning goals in this unit, useful for designing student assessments, among other purposes, include these:

1. Identify at least five techniques that advertisers use to get people's attention and make advertisements appealing.
2. Identify at least three techniques used to mislead people into believing that a product or idea is based on science when, in fact, it is not.
3. Identify at least one historical example in which a campaign was mounted to persuade people that scientists' conclusions were wrong because "the science is uncertain."
4. Identify three important questions to ask about a "scientific" claim that seems suspicious—questions that can help determine if the claim is true or not.
5. Explain the purpose of "a reverse image search" and give an example of why it might be useful in determining whether a claim is accurate or not.
6. Explain what peer review is and how it helps scientific knowledge advance.
7. Identify at least two scientific or professional organizations and explain what they do.

### Using the Videos Prepared for These Lessons

Teachers will need to pause the videos for these lessons at various points to allow students time for discussion, or for them to investigate certain claims. This Guide includes instructions about when to pause and why. Before using the unit, teachers should learn how to pause videos, and how to resume playing them.

### Assessing Students' Learning

Some teachers may want to use "exit slips" (some say "exit tickets") at the end of each lesson. Appendix 7 offers exit slip ideas for each of the first four lessons. These are optional.

Appendix 7 also includes suggestions for a test that students might take at the end of the unit. That test includes both short-answer questions and a type of performance assessment.

Whether or not to test students is up to you, the teacher. Suggestions for scoring the test are also included.

**Acknowledgments**

Thanks are due to those who pilot-tested this unit: Karla Orosco and her 7th grade students at Admiral Akers School at NAS Lemoore, CA; Katie Coppens and her 6th grade students at Falmouth Middle School in Maine; and Andrew McCullough and his 10th grade students at Brunswick High School in Maine. We appreciate their feedback and advice.

We would also like to thank NOVA staff at WGBH, including Ralph Bouquet, Tenijah Hamilton and Allison Eck, for producing more polished videos than were originally included.

## Lesson One: Misleading Advertising Supposedly Based on Science

**Background**: Research shows that understanding misleading argumentation techniques helps reduce their influence (Cook et al. 2017). Therefore, young people should learn about these techniques. In a society where almost everyone is exposed to thousands of advertisements each year, students should be aware of the ways that appealing language and images, misleading logic, and outright lies can be used to give the impression that a claim is "scientific" and truthful even when it is not.

For example, just because a cosmetic ad uses scientific-sounding jargon like "Total Soy Complex," that does not necessarily make the ad's claims true. Nor do evasions or half-truths in product ads, such as, "Many users report results in as little as one week." (What fraction of users? How were they selected? What types of results?). The Federal Trade Commission (FTC) helps review advertising, but only in certain instances; usually, consumers are on their own. The FTC's mission statement is "*Working to protect consumers by preventing anticompetitive, deceptive, and unfair business practices, enhancing informed consumer choice and public understanding of the competitive process, and accomplishing this without unduly burdening legitimate business activity.*" However, the FTC does not have sufficient resources to investigate each and every advertisement.

**Preparation**: Download and review "Resisting Scientific Misinformation Part 1.mp4," and be prepared to display this video with sound in your classroom. If the file is saved to a local computer, you can display it to the class regardless of the speed of your internet connection. Review this portion of the Teacher Guide, and also read the short Wikipedia entry about the Sensa diet.

**Procedure**: This lesson has five parts. Total class time is 45 minutes (estimate).

- **INTRODUCTION (8 minutes)**: Show and discuss the first part of the video (about 3 minutes) and explain the purpose of the unit. Reinforce the idea that advertising can be useful and truthful. Most ads are designed to be attention-getting and persuasive.

  It is helpful to pause for a brief discussion after the image of the L'Oreal (Lancome) cosmetics ad. Ask: Where do you encounter advertising? Have you bought anything after seeing an ad for it? Have you encountered "sneaky" ads? Which ones?

- **SENSA AD (10 minutes)**: Resume playing the video to show and discuss the 30-second Sensa video ad. Ask the class what claim Sensa made in this ad, i.e. what they wanted viewers to believe, and write that claim on the board. Then ask students to identify, one reason at a time, why people might find the ad appealing. List reasons on the board. (Some of the reasons ads are appealing are listed at the bottom of the next page.) If students do not mention the reference to science, or did not notice it, replay the ad asking the class to notice the "scientific" claim. After they have seen and discussed the video, let the class know that the Federal Trade Commission (FTC) investigated this Sensa weight-loss product and found that the company's claim that they had scientific evidence supporting Sensa's effectiveness was false. (Briefly resume and then pause

the video to show students the FTC announcement.) In 2014, the FTC ordered the company to return tens of millions of dollars to its customers, and the company producing Sensa went out of business.

- **"GENERIC" AD VIDEO (5 minutes)**: Tell the class that advertisers use many techniques to engage and persuade viewers. Resume the video to show the "generic advertising" video segment and ask students to use what they see in that video to add to the list of reasons why ads appeal to many people. (There is no need to list every reason; there are dozens! Ads are designed to get attention and be appealing. See partial list of reasons below.)

- **CREATE ADS (20 minutes)**: In small groups, students create a misleading print ad on one 8-1/2 by 11 sheet of paper. The teacher assigns ad topics using the list of ideas provided (see Appendix 1), or other ideas. REMIND STUDENTS TO INCLUDE A CLAIM ABOUT SCIENCE. (Tip: You could cut apart the list, putting each idea on a small piece of paper, and have students draw an idea from a hat or bag.) If there is time, have students show ads to the class. Collect ads before the end of class. They will be used again in the next lesson.

- **ASSIGN HOMEWORK (2 minutes)**: Each student should find an advertisement that seems related to science in some way: by making a scientific claim, using technical language, or referencing a scientific issue. Claims in these ads may be true or false. Promising possibilities include magazine or online ads (e.g., YouTube, Twitter, Facebook) for prescription or over-the counter drugs, cosmetics, dietary programs and substances, IQ boosters, and more. These ads will be used in Lesson 3.

**Additional information**: Responsibilities of the Federal Trade Commission (FTC) are here, and further documentation of the FTC's 2014 action against Sensa is here.

There are so many ways that advertising can be made appealing that perhaps no list can ever be complete. The goal in this unit is to make students more aware of how advertising works, not to be exhaustive. Ads might include these techniques, to name only a few:

- Show attractive people, such as celebrities
- Use striking designs, including eye-catching color or movement
- Appeal to emotions such as vanity or pride or the desire to be perceived favorably by one's peers
- Make unsubstantiated or exaggerated claims ("9 out of 10 doctors smoke our cigarettes")
- Obscure or simply do not mention risks or problems associated with a product.

## Lesson Two: A Special Misleading Argument, "The Science is Uncertain"

**Background**: Scientists are always adding to knowledge, even uncovering surprising things. But just because scientists seek to improve our understanding of the natural world does not mean everything scientists claim is uncertain. To the contrary; people in the modern world already know a great deal that is based on science. Students should learn that the argument "the science is uncertain" is sometimes used *intentionally* to mislead the public. Fortunately, social scientists have found that greater media literacy, including knowledge of this misleading technique, helps people resist misinformation (Kahne et al, 2017).

**Preparation**: Download and review "Resisting Scientific Misinformation Part 2.mp4" and prepare to display this video with sound in the classroom. If the file is saved to a local computer you can display it to the class regardless of the speed of your internet connection. If students are asked to conduct research during class, they will need access to computer devices and the internet. Practice searching the internet to determine whether or not the green flash at sunset is a real phenomenon or a case of scientific misinformation; you will model that search for students.

**Procedure**: This lesson has five parts. Total class time is about 45 minutes.

- **DISCUSS STUDENTS' ADS** (**10 minutes)**: Hand back ads students created so that each student receives someone else's ad. Ask students to identify an important technique used in that ad either to appeal or to mislead. (Tip: Some teachers ask students to use PQP for feedback: Praise something, Question something, and suggest Polishing something.)
- **SHOW VIDEO (5 minutes)**: Tell students scientific misinformation is not found only in advertising but also on Facebook and in many other media.
- **INVESTIGATE "GREEN FLASH" CLAIM (10 minutes)**: Let students suggest how to search the Internet to figure out whether the "green flash" is a real phenomenon or not. You, as teacher, do the searching on a display, modeling the search so the class can watch. This process raises many questions: What are credible sources? Why should we trust them? Are there websites you or your students are familiar with; are some sites unfamiliar? Are external references (e.g., those provided at the bottom of many Wikipedia articles) important and should we trust *those*? Write some of these questions on the board as they arise. Answers will become clearer as this unit continues. These are not easy questions.
- **STUDENTS INVESTIGATE OTHER CLAIMS (10 minutes)**: Refer to the list of claims in Appendix 2 and write it on the board or otherwise display it. Have students count off from 1 to 5 and ask each student to investigate the claim corresponding to their number by conducting research online. (Tip: Some teachers require that students check a minimum of three websites and provide brief notes about information on those sites.)

- **DISCUSS STUDENTS' FINDINGS (10 minutes)**: Ask students whether each claim is true or false. How do they know? How certain are they? What is the evidence? Can they cite more than one source?
    - ***ANSWERS***: See hyperlinks below for some of many available sources of information about each of the claims.

      (1) In theory certain jellyfish can live forever; in practice few do, if any.
      (2) The severe flu outbreak in 2017 was NOT caused by defective flu vaccine; that is misinformation.
      (3) Nibiru or Planet X is fiction, not fact.
      (4) Ball lightning is controversial, but many scientists believe it is real.
      (5) Using fruit flies (which can model many human diseases), scientists have found compounds that reverse symptoms of Alzheimer's.

## Lesson Three: Asking Questions about a Dubious "Scientific" Claim

**Background**: The first part of this lesson explores, from multiple perspectives, what questions to ask about a dubious claim. The last activity in the lesson focuses on scientific institutions because they are among the most reliable sources of information about science.

It would be great if there were exactly one procedure that we could always use to determine whether a claim is true or not. Unfortunately, that is not the case. Nonetheless, students are likely to have good intuition about important questions to ask about claims, and we should build on their intuition. Is an advertiser trying to fool me? Which websites or other sources are credible? Why should I trust any particular source? These are good questions. (Note that the question "How do scientists know something is true?" will be addressed in Lesson 4.)

When investigating a dubious scientific claim, one will often encounter articles or websites from an organization or institution with specialized knowledge of science. For ball lightning one might find an article in *Physical review letters* published by the American Physical Society. For the green flash one might encounter a web page from San Diego State University. Scientific institutions have been essential to science for centuries, and students should have at least a rudimentary knowledge of such institutions. That is the focus of the last activity in this lesson.

**Preparation**: Download "Resisting Scientific Misinformation Part 3.mp4" and prepare to show it in class. Before class be sure to watch the video, including the video segment from Quartz. Make a short list of a few good questions to ask about dubious scientific claims in case students do not suggest questions. Also, try to find an ad for a prescription medication, in case none of your students brings one to class (homework for Lesson 1). In talking about ads—the final activity in this lesson—pharmaceutical advertisements are likely to identify the Food and Drug Administration (FDA) as an authority. The FDA is one of the organizations that students investigate in this lesson.

**Procedure**: This lesson has 6 parts. Total class time is about 45 minutes (estimate).

- **WITH STUDENTS' HELP, LIST SOME QUESTIONS ON THE BOARD YOU AND THEY POSED ABOUT THE "GREEN FLASH" OR OTHER CLAIMS (3 minutes)**: In this lesson students will learn about a number of useful questions to ask in order to investigate a "scientific" claim. But there is no single set of questions that is correct for every questionable claim.
- **SHOW THE FIRST PART OF THE VIDEO, INCLUDING THE QUARTZ SEGMENT ABOUT "FAKE NEWS" (6 minutes)**: Scientific misinformation is similar to "fake news." Similar but not identical questions can be used to investigate most any questionable claim we encounter in media. This lesson emphasizes similarities with "fake news." However, science is not identical to history, current events, or other fields in which "fake news" is a problem. Notably, scientists have developed unique methods to determine the truth about natural phenomena, such as using peer-reviewed journals. The next lesson focuses on how scientists reach their

conclusions. Resume playing the video after two class discussions (describe in the two bullets below).

- **DISCUSSION ABOUT USEFUL QUESTIONS AND SOURCES. (5 minutes)**: Discuss what you watched with the class. Question topics that are described in the video (**P**urpose? **A**uthor? **R**elevance? **C**urrency? **S**ources?) are guidelines, good starting points. However, there is no "formula" to figure out what is accurate and what is not. (Tip: If five sets of questions seem too many for your students, you can focus on the acronym SAP—for Sources, Author, and Purpose—highlighting what are usually the three most important questions to ask. "SAP" is an easy acronym to remember because a "sap" is a "fool." No one wants to be fooled by misinformation!)

  Some questions to pose to the class for discussion include:

  - Question: Did you (i.e., students) see any claims in the past classes whose Purpose was to sell a product? If so, which ones?
    - (Answer: Sensa and L'Oreal ads).
  - Question: Are *all* advertisements based on false claims, with the Purpose to mislead you?
    - (Answer: Of course not! An appealing ad, as almost all ads are, is not the same as a false or intentionally misleading ad.)
  - Question: Was it clear who the Author was for each claim investigated in the last class?
    - (Answer: In many cases 'no,' and even if the author was identifiable—e.g., someone named "Miles Johnson" posted about the Green Moon—we know little about them; there is no reason to think they are experts. The person who posted the video about the green flash admitted he did not know if the claim is true; he is no expert. However, as students conducted research, e.g. about the green flash, authorship or at least the name of websites they referenced became clear, and some are more credible than others.)
  - Question: In judging the accuracy of a claim (such as existence of the green flash, or ball lightning), which Sources can we trust?
    - (Answer: A discussion of sources leads to questions about which websites or other sources to trust. What about Wikipedia? That's the next topic. Note that a comprehensive scientific explanation of the green flash at sunset was recently added to YouTube at this URL: https://youtu.be/nMq3cqO__Yw. However, it may be too complex for many students.)

- **CAN WE TRUST WIKIPEDIA (DISCUSSION)? (5 minutes)**: This is a challenging yet important topic. Schools may have their own policy about students' *citing* Wikipedia (or any other encyclopedia) but no one is likely to stop students from *using* Wikipedia. Many studies find that Wikipedia provides accurate information about scientific topics much more often than not. One way that Wikipedia can be useful is in the footnotes and references to other sources that are supplied at the bottom of many articles. For example, the Wikipedia article about ball lightning includes more than 100 footnotes, many of which lead to articles in scientific journals.

  For science educators and science students, Wikipedia can be a useful tool. Like every other tool, sometimes it is appropriate to use it, and other times it is not. It is true that articles and reports by scientists will be more authoritative than other sources, but they are often difficult for laymen, particularly young students, to locate and understand. News articles, encyclopedias, and textbooks are typically easier to understand than reports and journal articles; however, none is likely to be 100% accurate.

- **EXPLORING SCIENTIFIC INSTITUTIONS (15 minutes)**: Resume play of the remainder of the video (about 2 minutes).

  Ask each student to use a computer device to investigate one of the five scientific institutions in the video—the CDC, WHO, AAP, FDA or the National Academies. (You could add or use other institutions if you wish, such as the IPCC.) Ask students what they discovered about each organization. Do we expect that these organizations are usually credible sources for information about science? Why or why not? (Tip: Some teachers will want to prepare a handout for students, including, for example, the list of scientific and professional organizations to be investigated and their URLs, plus the information to be gathered about these institutions, and also a reminder of questions to ask about claims, based on the acronyms PARCS or SAP.)

- **DISCUSS ADS STUDENTS COLLECTED AS HOMEWORK TO LESSON 1 (11 minutes)**: Did any students collect a pharmaceutical product ad? Which scientific agency or organization was cited in that ad? Besides pharmaceuticals, did any ad cite specific scientific research that someone could find and read? Did students discover any ads they believe are promoting scientific misinformation? If so, why do they think so? Which questions (PARCS) seem most appropriate to the ad with misinformation? (Tip: It is not necessary to discuss each advertisement collected by the students.)

Reverse image searches are mentioned in a video in this lesson and some teachers may want to provide more examples to students. Here is an article about a fake photo of political leaders surrounding Vladimir Putin. (Google search for the image, and you will also find the original, undoctored version.) And here is an article about other "infamously altered" photos. Searching the internet for "misleading photos in the media" leads to still more sources of information, including examples of misleading photos.

## Lesson Four: The Scientific Process

**Background**: How do scientists create new knowledge, and why should we have confidence in their conclusions? At the heart of the matter is the community of scientists and scientific organizations that manage and conduct peer review. Over time peer review hones past understandings of the natural world and replaces them with better ones. Although the development of scientific knowledge can be slow (for example, we are still trying to understand cancer even after many decades of research), nonetheless the benefits of science are visible almost anywhere we look. (See Appendix 5 for further information about the nature of science.)

One goal of Lessons 3 and 4 is to illustrate the value of scientific organizations (the American Academy of Pediatrics and other groups) in reviewing and synthesizing scientific research, and then communicating it in useful forms. Practice 8 of the Next Generation Science Standards (NGSS) is "obtaining, evaluating, and communicating information." Scientific organizations have been critically important to that practice for centuries.

**Preparation**: If you want additional information about the peer review process, here is a useful three-minute YouTube video. Review optional Lesson 5 (below) and decide whether to use it. Download "Resisting Scientific Misinformation Part 4.mp4."

**Procedure**: This lesson has 3 parts. Total class time is about 45 minutes.

- **SHOW THE VIDEO (4 minutes)**: *How* do scientists reach consensus, providing reliable conclusions about the way the natural world operates? *Why* does the scientific process produce trustworthy information? Are there modern parallels to people accepting false claims about blood-letting? [Example: anti-vaccination advocates.]
- **DISCUSS PEER REVIEW (7 minutes)**: Ask students: What is peer review? Why is peer review important? Can you give an example of a scientist making a mistake? How are scientific errors corrected? What are examples of knowledge gained by scientists? Is it sufficient to have "a natural instinct for science" to know which claims are true?
- **CONDUCT RESEARCH AND WRITE A SHORT NOTE ABOUT INCREASING INFANTS' IQ (25 minutes)**[*]: Ask students to imagine that their aunt or a friend of the family has a new baby and wants advice. Students should write a note and in a few paragraphs provide advice to parents of very young children, ages zero to 18 months, who want their child to grow up to be intelligent, specifically addressing whether video or other media use will help babies and toddlers under 18 months old develop their minds better and more quickly. (See resource list below.)

  Students could work individually, in small groups, or as a whole class. We recommend starting with a **whole-class approach** to conduct research online under the teacher's direction so all students are engaged, not off topic. (Which approach you use depends on the availability of computer devices, on how well your students read and write

[*] The subject of vaping, or e-cigarettes, would be a good alternative topic for research by students. See Appendix 4.

English, and other factors.) (Tip: You may want your students to include in the written note a list of the sources they used, perhaps in a standard format for references.)

**Background**: For more than 20 years, media products have been marketed that promise to raise babies' IQ scores, increase their brain capacity, teach them language at an earlier age, or otherwise improve their cognitive development. One of the earliest product lines was called Baby Einstein. Even now, new products (apps, in this case) are being marketed that make claims like the following: "[This product] *literally opens infant brain receptors resulting in increased attention span, profound expansion of memory, greater affinity for language development and dramatically increases your child's ability to rapidly process auditory information."* (See Appendix on last page of this Guide for information about this product. However, it does not seem appropriate to name the product in class because the company's claims are not credible, and you do not want to promote the product.)

Here are several online sources of information about very young children and media that can be referenced during class (and surely there are others):

- 2016 recommendations from the American Academy of Pediatrics (AAP) about media and young minds. (An Adobe Acrobat version of the same set of recommendations is *here*.) Because this document is long, help students focus on the Abstract, Conclusions, and Recommendations—those sections that most concisely provide information about using media with very young children. For example, here is one pertinent paragraph in Recommendations to Families:
  "*Avoid digital media use (except video-chatting) in children younger than 18 to 24 months.*"
- A Wikipedia article about Baby Einstein
- A 2017 article from *Slate*, The Rise and Fall of Baby Einstein

Here, for another example, is one paragraph from the AAP's 2016 recommendations for all young people (not just infants) (see this URL):

*"The AAP recommends parents prioritize creative, unplugged playtime for infants and toddlers. Some media can have educational value for children starting at around 18 months of age, but it's critically important that this be high-quality programming, such as the content offered by Sesame Workshop and PBS. Parents of young children should watch media with their child, to help children understand what they are seeing."*

**Additional information**: Vaping, using e-cigarettes or other devices, has quickly become popular among high school students. There is a great deal of misinformation circulating about vaping, such as that vaping is not addictive even if the vapor includes nicotine. At the end of this unit (Lesson 4 or 5) some teachers may want their students to learn more about vaping. One good, short resource is an NBC News video: https://www.nbcnews.com/think/video/how-e-cigarettes-like-the-juul-are-co-opting-the-language-of-wellness-1259469891755

## Lesson 5: The Scientific Process, Part 2 (Optional)

**Background**: For some teachers, four lessons about scientific misinformation are sufficient. Others may want to devote more time, a fifth lesson, in order to accomplish any of several goals: highlighting high-quality work on the "advice note" students wrote in Lesson 4; expanding class discussion of peer review as a fundamental part of the scientific process[*]; and, assessing students' understanding of this unit. (Again, Appendix 5 includes more information about the nature of science.)

**Preparation**: At the conclusion of Lesson 4, collect the notes that students wrote to their aunt or a friend that provided advice about raising an intelligent infant or toddler. Choose one or more examples of notes that you think are of high quality. Also, watch this YouTube video, The Peer Review Process in 3 Minutes: https://www.youtube.com/watch?v=rOCQZ7QnoN0. Lastly, use the Learning Goals for this unit (page 2) to create a brief test or assessment, or use the one provided in Appendix 7. (You might also find actual examples of scientific information or misinformation for students to investigate and write about as a final project for grading, similar to what they did as part of Lesson 2.)

**Procedure**: This lesson has four parts.

- **REVIEW ONE OR MORE NOTES STUDENTS WROTE IN LESSON 4 (10 minutes)**: Display one or more notes (probably without students' names) so the class can see them. Ask the class: What makes the advice credible? Why should a recipient believe this advice is any good? What do you think about the trustworthiness of any sources cited in the note?
- **SHOW CLASS THE YouTube VIDEO ABOUT PEER REVIEW AND DISCUSS IT (10 minutes)**: The video is about 3 minutes long. After they watch it, ask the class questions like: What is a "referee" for a scientific journal? What is the role of the editor of a scientific journal? What percentage of articles submitted to prestigious journals might be rejected, and what percentage accepted? What are examples of knowledge gained through scientific research that might appear in a scientific journal article?
- **ASK FOR FEEDBACK ABOUT THIS UNIT (5 minutes)**: Ask students in what ways they believe this unit was useful to them. What was interesting to them, and why? How might the lessons be improved? (Note: any suggestions you provide to us, the developers, after using this unit would be appreciated.)
- **ASSESS STUDENTS' LEARNING (20 minutes)**: Using test items you develop, or topics you identify that students are asked to investigate (to find out if the claim is true or not), or the test included in Appendix 7, assess what students have learned.

[*] In recent years some "scientific" journals have appeared that do not use peer review, or that have lax standards for accepting articles. High-quality journals are essential to science and some accept as few as 10% of the manuscripts they receive.

## References


Cook J, Lewandowsky S, Ecker UKH. 2017. Neutralizing misinformation through inoculation: Exposing misleading argumentation techniques reduces their influence. *PLoS ONE* 12(5): e0175799.

Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. 2012. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change* 2: 732-725.

Kahne, J. & Bowyer, B. 2017. Educating for democracy in a partisan age: Confronting the challenges of motivated reasoning and misinformation. *American Educational Research Journal 54(1): 3-34.*

National Science Board (NSB). *2018 Science and Engineering Indicators*. Alexandria, VA: National Science Foundation. Page 7-3.

NGSS Lead States. 2013. Appendix H of the Next Generation Science Standards, *Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards*.

Oreskes, N. & Conway, E. M. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York: Bloomsbury Press.

van der Linden, S. Leiserowitz, A., Rosenthal, S. & Maibach, E. 2017. Inoculating the public against misinformation about climate change. *Global Challenges*, 1.


## Further Reading

Two useful books about scientific misinformation are specifically aimed at teenagers, and another (*Bad Science*, by Goldacre) is also accessible for young people:


Cunningham, D. (2013). *How to Fake a Moon Landing: Exposing the Myths of Science Denial*. New York: Harry N. Abrams.

Goldacre, B. 2008. *Bad Science: Quacks, Hacks, and Big Pharma Flacks*. New York: Farrar, Straus and Giroux.

Grant, J. (2014). *Debunk It! How to Stay Sane in a World of Misinformation*. San Francisco: Zest Books.

# Supplementary Materials

## Appendix 1 (Lesson 1): Potential Topics for Student-Created Advertisements

1. Slimming cream: Rub it on and fat melts away
2. Muscle ointment: Rub it on your muscles and watch them double in size
3. Brain tapes: Play them at night to increase your IQ
4. Cure insomnia with essential oils
5. Special soda that protects against cancer
6. Buy this book … for the secret to a lifetime of wealth with real estate
7. Detox juice: Clears your body of germs—naturally!
8. Scientifically proven: Learn a foreign language in 5 days
9. Magnetic headband: Double your rate of learning
10. Champion sneakers: Run faster, jump higher, cut your reaction time in half
11. Sculpting clay (or other toy): Double your child's creativity!
12. Brain-building dog food – increase your pet's intelligence
13. Food supplement keeps ticks and mosquitoes away from you all season
14. Unique pen color influences your teacher to give better grades
15. Zit-erasing chocolate candies
16. BOOST! Install app on cellphone and increase brainpower when using your phone
17. Pillow gives you deeper sleep – it's like sleeping 2 hours extra (See claim here.)
18. Specially-designed glasses double your reading speed – get all As!

## Appendix 2 (Lesson 2): “Scientific” Claims for Students to Consider

1. Some jellyfish are immortal; they live forever
2. In 2017 defective flu vaccine caused people who had their flu shot to have more severe cases of flu
3. Nibiru, also called Planet X, will cause disasters by hitting the Earth or passing close by it
4. Some lightning looks like a sphere that moves, and is called ball lightning
5. Fruit flies can get Alzheimer’s disease

## Handout for Lesson 3: Asking Good Questions about a Dubious Claim

The best way to investigate a questionable scientific-sounding claim is to ask good questions. You can remember the following five sets of questions using the acronym PARCS.

- **Purpose**. Why was the information made available? Is it because somebody is selling something, in which case we should be extra careful before believing what they say? Is the purpose to stir up your emotions, OR to provide information?
- **Author**. Where did the claim come from? Is the claim made by a qualified scientist, a respected group or website? Can you even tell who the author is?
- **Relevance**. Does the claim apply to you, or to a question you want to answer? Maybe you read a claim about a diet for people who have a disease, but the diet is not relevant for you. A survey might be accurately reported but not apply to people of your age group or who live in your town.
- **Currency** (like *current* events). When was the information published? Is it up-to-date? For instance, as we saw in the video, maybe an old picture is being used to fool you.
- **Sources**. Are there good references provided so you know what experts think? Do well qualified people have a different point of view than the one presented?

Three of those questions are usually the most important ones to ask. You can remember them using the acronym SAP. A "sap" is a fool, and no one wants to be fooled by misinformation!

- **Sources**. Are there good references provided so you know what experts think? Do well qualified people have a different point of view than the one presented?
- **Author**. Where did the claim come from? Is the claim made by a qualified scientist, a respected group or website? Can you even tell who the author is?
- **Purpose**. Why was the information made available? Is it because somebody is selling something, in which case we should be extra careful before believing what they say? Is the purpose to stir up your emotions, OR to provide information?

## Appendix 4 (Lesson 4)

### Raising Infants' and Toddlers' IQs

A company called Nuryl is marketing what they call a "baby training app." In a video they posted on YouTube, pregnant mothers are even encouraged to play music to a baby growing inside their womb!

(See screenshot below, from the video.)

In that video the announcer says,

*"So what is Nuryl? Using scientific principles of infant brain plasticity our content delivered through a mobile application literally opens infant brain receptors resulting in increased attention span, profound expansion of memory, greater affinity for language development and dramatically increases your child's ability to rapidly process auditory information."*

### Vaping and E-Cigarettes

Vaping with e-cigarettes or related devices has quickly become popular among high school students. There is a great deal of misinformation circulating about vaping. Some teachers may want their students to learn more about vaping, perhaps as an alternative to focusing on false claims about raising infants' IQ. At the time this Guide was prepared, one website, and probably others, falsely claimed that nicotine is not addictive (https://www.vapes.com/blogs/news/vaping-news-harvard-study-shows-nicotine-is-not-addictive). Students could be asked to write about that claim. Be aware that because vaping is potentially so addictive, the rules about marketing e-cigarettes to young people may change quickly. One useful, short resource about vaping is an NBC News video: https://www.nbcnews.com/think/video/how-e-cigarettes-like-the-juul-are-co-opting-the-language-of-wellness-1259469891755

## Appendix 5: The Nature of Science[1]

Science is the pursuit of explanations of the natural world. It is deeply rooted in the minds of human beings, who for millennia have demonstrated a need to understand the world around them. In some cases, our need to know originates in satisfying basic needs in the face of potential dangers. Scientific research is sometimes based on natural curiosity and, in other cases, it is based on the promise of a better, more comfortable life.

The Next Generation Science Standards (NGSS) points out that being well informed about scientific findings is not the same thing as understanding science itself ("the scientific process"). Both are important goals for students; the NGSS specifically makes it clear that students should understand the nature of science. Understanding the nature of science helps students know **how** scientific knowledge is developed and **why** they can have confidence in that knowledge.

According to the NGSS, there are eight basic understandings about the nature of science:

1. Scientific Investigations Use a Variety of Methods
2. Scientific Knowledge is Based on Empirical Evidence
3. Scientific Knowledge is Open to Revision in Light of New Evidence
4. Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
5. Science is a Way of Knowing
6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems
7. Science is a Human Endeavor
8. Science Addresses Questions About the Natural and Material World

Although a full discussion of the nature of science requires more than one page, we note that a sequence of Claim-Evidence-Reasoning is at the heart of science, notably in the peer review process. Scientists make claims about the natural world, present evidence to support their claims, and use reasoning to reach conclusions and persuade their peers. Scientific knowledge is never complete, but grows and is revised as new evidence is discovered, linked to existing evidence, and made available for review by other scientists. Familiar examples of revisions in scientific knowledge include replacing humans' beliefs that the Earth is the center of the solar system with a heliocentric model (the Copernican revolution) and replacing the belief that Newton's laws of motion are sufficient to understand motion of all types with Einstein's revolutionary ideas, among many others.

The advice students wrote about raising infants' IQs should reflect knowledge scientists have developed over many decades of research. In the absence of accepted, peer-reviewed evidence, amazing new claims about making babies smarter should be treated skeptically, simply as claims rather than as accepted scientific knowledge. Responsible scientific and professional organizations can be trusted to gather, synthesize and disseminate high-quality research reflecting current scientific knowledge.

[1] This page is based on Appendix H of the Next Generation Science Standards, *Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards*.

## Appendix 6: Additional Science-related Claims Students Could Investigate

These claims could be used for extra credit, for students who complete assignments early, as a replacement for one or another claim included in Lessons 1-4, or in other ways.

Note that in Lesson 1 students are asked to collect advertisements that include "scientific" claims, and these are another rich source of examples that might be worth investigating—but it can be difficult to investigate some of those in part because advertisers may make unusual claims yet not include any sources that students can check.

1. *Time* magazine published an issue in 1977 whose cover reads, "How to Survive the Coming Ice Age," demonstrating that climate scientists have changed their conclusions about climate change. (See such a claim and image here and an article debunking the claim here. A **reverse image search** may be useful.)
2. Although it might seem an unlikely place to see one, a photo proves that a killer whale was spotted off the coast of Maine. (One post making that claim is here and an article debunking the claim is here. A **reverse image search** may be useful.)
3. Research confirms that vaccines cause autism. (An example of this claim can be found here. A piece by the CDC about vaccine safety that debunks this claim is here.)
4. For the first time in 666 years Halloween will fall on Friday the 13th. (Think about it! Halloween always occurs on October 31.)
5. Putting fluoride in the water to help prevent tooth decay is in fact a communist plot to undermine Americans' health. (This is a famous, decades-old example. During the 1950s and 1960s some conspiracy theorists claimed this was true. See a Wikipedia article about water fluoridation controversy, or about the John Birch Society.)
6. Video games contribute to increased youth violence and bullying. (Note that conducting research about this claim may prove complex and challenging. One starting point might be https://videogames.procon.org/.)
7. Not getting enough sleep is linked to teenage depression and anxiety. (See this *U.S. News and World Report* article, for example.)
8. Vaping and e-cigarettes are safer than smoking and pose little risk to young people's health. (Information from the CDC can be found here.)
9. A student at the University of Miami has created a hybrid marijuana-strawberry plant. (Snopes debunked this claim here.)
10. Antiperspirants that include aluminum cause cancer. (E.g., this claim can be found here. The National Cancer Institute has debunked the claim. Because the website with the claim cites some scientific journals some people may find the evidence ambiguous.)

## Appendix 7: Assessing Students' Learning

This section is divided into two parts. The first is a series of "exit slips," quick assessment questions you can ask students at the end of each lesson. The second part is a test that can be administered after teaching the unit. Using any of these assessment materials is optional.

### Exit Slips

Students can respond to these prompts with a few sentences written on an index card.

**Lesson One**

At the start of class, ask students to identify and write down two techniques advertisers might use to make their products attractive.

On the way out: Ask students to write on an index card (1) a **scientific** claim made in the Sensa ad. Ask them (2) to label each of these two features of the ad as either misleading (M), attractive and *not* misleading (A), or not attractive and not misleading (N): people dancing; shiny sprinkles. Also, ask them to identify and label (M, A, or N) one more feature of the ad besides those two.

**Lesson Two**

At the start of class, ask students to note down an example of an advertisement or campaign they have seen in the past that uses misleading scientific claims – other than Sensa.

On the way out: Ask students to note down one or two examples of campaigns to confuse or mislead people by claiming that "the science is uncertain."

**Lesson Three**

Ask students to note down one method to use to tell whether a scientific claim is accurate or not (e.g., ask a parent, Google it, think about it …).

On the way out: Ask students to note down what each of these letters stands for in the mnemonic for how to evaluate a scientific claim: P, A, R, C, S.

**Lesson Four**

At the beginning of class ask students to write one or two sentences about what they think "peer review" means. You could ask the same question at the end of class. (There is no other exit question for Lesson 4, because for homework students are working on a performance assessment, their note about raising infants' IQ scores.)

### An End-of-Unit Test

The test on the next two pages can be duplicated and handed out to students. Suggestions for scoring the test are provided on page 24.

**Scientific Misinformation**

Name: _____ Date: _____

1. Choose **one** of the following organizations and explain what it does:
   (i) AAP: American Academy of Pediatrics (ii) WHO: World Health Organization
   (iii) CDC: Centers for Disease Prevention and Control (iv) National Academies
   (v) FDA: Food and Drug Administration

2. Explain what "peer review" means in science, and why it is important.

3. Presented with a supposedly scientific claim it is often a good idea to ask about sources. Explain what "sources" means here, and why it can be important to check them.

4. Suppose a new vaping product is introduced, called VAPEiD. The company's advertising claims that because their pods contain less than half the nicotine of the best-selling vape pods, VAPEiD is not addictive. Circle three good strategies to check if that claim is true:

   i. Ask my friends
   ii. Ask a teacher
   iii. Read about nicotine on Wikipedia
   iv. Read an electronic book called *The Art and Science of Vaping*
   v. Google "vaping" and read the top five posts that come up
   vi. Read a statement from the American Academy of Pediatrics about vaping
   vii. Read a statement from the American Association of Vaping
   viii. Search to find what vaping products celebrities use

5. Circle the claims or ad campaigns below that are examples of trying to mislead people by claiming that "the science is uncertain"?

   i. Buckle up (use seatbelts)
   ii. Got milk? (to encourage people to drink more milk)
   iii. Don't worry about second-hand smoke (meaning people smoking tobacco nearby)
   iv. The first "green moon" in more than a century will be visible soon
   v. Climate change is not proven
   vi. Vaccinations cause autism

6. If a company called I-Scream is advertising a brand of premium ice cream made with real cream, which of the following techniques might be considered deceptive by the Federal Trade Commission? Circle those.

   i. Showing a celebrity eating I-Scream
   ii. Photographing mashed potatoes in place of I-Scream (preventing melting of ice cream)
   iii. Saying that I-Scream has zero calories
   iv. Using only thin, attractive people in I-Scream ads
   v. Claiming that I-Scream is part of "the good life"
   vi. Suggesting that eating I-Scream helps prevent cancer

## Scoring the Test Questions

Here are suggested ways to score the questions.

### Item 1

Use a rubric. For each organization, students might identify (1) examples of the topics about which the organization is concerned, (2) whether or not it is a government agency, (3) some measure of its size, (4) why it is a trustworthy source of scientific information, and (5) how it works. Providing three of these might give students 100% credit for their answer.

### Item 2

Peer review is (1) associated with scientific journals and certain scientific organizations (such as the International Panel on Climate Change, the IPCC), (2) involves reviews by experts in a particular scientific discipline, (3) results first in acceptance or rejection of manuscripts submitted, and then (4) publication of the manuscript (whether in a journal, or as a report, or in some other form). Also (5) peer reviewers are usually not identified (reviews are "blinded") so that the reviewers are able to write honestly, and (6) an editor is usually responsible for managing the process of peer review. Finally, (7) peer review is important because scientists making new claims must present *evidence* to support their claim and *reasoning* to explain how the claim and the evidence fits with or changes accepted scientific knowledge. If reviewers find the evidence or the reasoning faulty, the manuscript will not be accepted.

To earn 100% credit, students might need to identify at least three of these characteristics of peer review, including an explanation of why it is important.

### Item 3

Anyone can make a claim, such as Martians built the Great Pyramids in Egypt. We want to know what sources of information were used to make that claim so that we can decide whether the sources are trustworthy and, in some cases, check the sources ourselves (e.g., read the work of scientists whose work supports the claim). Claims without trustworthy sources should be viewed skeptically. Perhaps they are true, but without trustworthy evidence we can't be sure.

Students' answers should be consistent with the explanation above.

### Item 4

Four good strategies to find out whether nicotine is addictive include: (ii) Ask a teacher, (iii) Read about nicotine on Wikipedia, (v) Google vaping and read the top five posts that come up, and (vi) Read a statement from the American Academy of Pediatrics about vaping.

Note that reading only the top five posts from Google on any topic is a gamble because sometimes the most reliable posts are not among the top five. In the case of vaping, the strategy would work out well. Perhaps the same thing could be said about some of the other "good strategies," e.g. asking a teacher might work well or not, depending on the teacher. Still, these four are better strategies than items i, iv, vii, or viii.

### Item 5

Items (iii) second-hand smoke won't hurt you, (v) climate change is not proven and (vi) vaccinations cause autism are all cases where proponents of this misinformation claim that "the science is uncertain." Vaccinations were not a topic in this unit, so we recommend giving full credit if students identify at least two of the three correct answers.

### Item 6

Item (iii) claiming that I-Scream has zero calories and (vi) claiming that eating I-Scream helps prevent cancer should result in complaints to the Federal Trade Commission and then, one hopes, action by the FTC. After all, such claims require evidence, which does not exist.

Although using mashed potatoes to simulate ice cream may seem deceptive, no consumer agency is likely to care. If they did, then any ad that used Photoshop or other typical means to make products look more attractive would be at risk. We are not aware that such procedures are prohibited; indeed, they are probably typical because ads are intended to be appealing.