Lesson 3: Why Do We Care About Science?

Introduction

Version 0002

This document is Lesson 3 of the SEAChem2020 open source chemistry curriculum program for secular homeschoolers. This version was current as of 11 August 2017. To if there is a more current version of this document, visit www.SEAChem2020.org.

Table of Contents:

We welcome any help you are willing to provide in supporting this project. Even if you're not a chemist or a professional educator, you can help in the following ways:

- **Let us know about minor fixes**. If you find anything from a factual to a stylistic error, or even a typo, let us know by using this form.
- **Let us know if you find big problems**. Does something need rewriting? Let us know by contacting us using this form.
- **Give us your resources**. If you've done one of these lessons and have put something cool together, email us at misterguch@chemfiesta.com so we can include it!
- **Volunteer**. Do you want to edit this curriculum? Do you have things to add? Would you like to write some of these lessons? Let us know!
- **Publicity**. Tell your friends about these resources. When the community grows, the project keeps growing!

Thank you for using this resource, and please consider helping out!

Lesson 3: Why Do We Care About Science?

Parent Reference

Objective: To learn why we should learn science in general, and more specifically, chemistry.

This lesson contains the following:

- Text: Why Do We Care About Science?
- Lesson glossary
- Practice sheet
- Activity: Make Your Voice Heard
- Assessment
- References for further study

Additional resources needed: Internet-capable computer

How to use this material:

This lesson is set up to be used in the following way. During the course of this lesson, your child should:

- Read the material in the text.
- Rewrite the material in their own words. (Optional but recommended).
- Complete the practice sheet.
- Write their own practice sheet for the material, complete with answer key. (Optional but recommended).
- Complete the lab activity.
- Write their own lab activity for the material, complete with suggestions on how to best perform the lab. (Optional but recommended).
- Take the assessment to ensure they understand the material.
- Write their own assessment, along with solutions. (Optional but recommended).

These steps should be followed by a debrief, in which you and your child will discuss the lesson. Please send us your suggestions, as well as any materials your child writes (text, practice, lab, assessment) so that we may incorporate it into the curriculum.[1]

Practice Sheet:

This practice sheet is a mixture of the stuff universities expect and open-ended problems that challenge your child to think creatively (the good stuff). When your child is finished with the practice sheet, we recommend that they spend a few minutes writing their own practice sheet. Teaching is the best way to learn something, and by teaching others your child can help to teach him/herself. Please submit any practice sheets to SEAChem2020 at misterguch@chemfiesta.com.

1 *Any submitted material added to the curriculum will be licensed under the same Creative Commons license as the rest of this material and will be free for others to use and adapt. Please make sure your name is included somewhere on the submitted resource(s) if you wish to receive credit for your work. All submitted resources may be edited for accuracy, formatting, and style.*

Lab:
The information about the lab is included in the lab document itself.

Assessment:
The assessment in this lesson, as in all of the lessons, is meant to not only indicate whether your child has learned the material, but to push them to think even further than they have before. After all, assessments should be part of the learning process, too. When your child is finished with the assessment, we recommend that they spend a few minutes writing their own assessment. Teaching is the best way to learn something, and by teaching others your child can help to teach him/herself. Please submit any assessments to SEAChem2020 at misterguch@chemfiesta.com.

Lesson 3: Why Do We Care About Science?

Now that we've defined science in general and chemistry specifically, it's time to ask ourselves the *really* important question: Why do we care about learning science? Can't we live a fulfilling and happy life without learning science?

Well, yes. Even without scientific knowledge, you can still live a wonderful life. Unless you have a passion for science, you'd probably never even notice that you were missing anything. It's not true that “you need to learn science to be happy.”

So, let's go back to the original question: “Why do we care about learning science?”

You have a responsibility to society to be well-informed

We're all a part of something bigger than us. We're members of our local community, our country, and the world community at large. And we have a responsibility to all of them to be well-informed so that we can make decisions that benefit everyone.

The social contract

Thomas Hobbes (1588-1679) described what he called the social contract, which states that all people agree to give up some of their freedom to the government in return for a civilized society. In this view, the government gets its power through the consent of the ruled, whose beliefs and opinions affect its policies. From this it follows that it is the responsibility of the citizenry to be well-informed so that the government can make and enforce appropriate policies.[2,3]

You have undoubtedly seen cases where a faulty understanding of science has led to poor decision-making by both politicians and ordinary people. Though it's easy to dismiss these poor decisions as political pressure or stupidity, it's probably fairer to say that most of these bad decisions are made by people who don't understand the facts. *This* is why we need to learn science: So we don't become one of the poorly-informed individuals who make and support bad decisions that harm society as a whole.

2 *These ideas were outlined in Hobbes' Leviathan (1651) and outlined in Part IV: Of the Kingdom of Darkness. As the name would suggest, a great deal of the trouble comes through the misapplication and misinterpretation of Scripture. However, in a larger sense, Hobbes explains how the source of trouble is ignorance and willful suppression of truth, as described by his description of the Church suppressing Galilean teachings of science.*

3 *The painting of Thomas Hobbes shown here is in the public domain.*

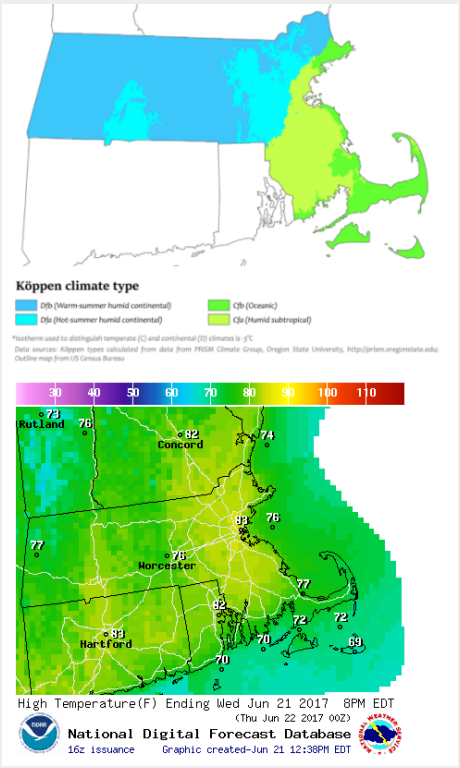
Here are some of the issues where a faulty understanding of science affects society as a whole:

- **Global warming**: Though scientists overwhelmingly believe that human-induced global warming is taking place[4,5], 29% of Americans believe that scientists are divided on the issue and 32% believe that human-induced global warming is not taking place at all.[6] Because the global warming policies of each nation plays a huge role in stopping the warming trend, we must all ensure that we are knowledgeable enough about the physical chemistry of global warming that we can elect leaders who will act properly to minimize global warming's effects.

Weather vs. Climate

We've all heard a lot about climate change, but what's the difference between climate and weather? Weather is the atmospheric activity that's going on right now. Your weather may be rainy with a temperature of 15° Celsius on one day, and sunny with a temperature of 25° the next. Climate, on the other hand, is the average of the long-term weather patterns for a region. While the weather today in the Sahara desert may be rainy, it is still a desert because, on the whole, the Sahara gets very little rain.

One of the misconceptions about climate change is that weather and climate are the same thing. A warm winter day is not evidence of global warming, nor is a cool summer day evidence against it. Only an overall long-term pattern of weather change is evidence of climate change.[7]



Climate map of Massachusetts (top); weather map of the same area on 6/21/17.[8]

4 *97-98% of climate scientists believe that human-induced global warming is taking place. Anderegg, William R L; Prall, James W.; Harold, Jacob; Schneider, Stephen H. (2010). "Expert credibility in global warming".* Proc. Natl. Acad. Sci. U.S.A. *107 (27): 12107–9. Bibcode:2010PNAS..10712107A. PMC 2901439 . PMID 20566872. doi:10.1073/pnas; Cook, John; Nuccitelli, Dana; Green, Sarah A.; Richardson, Mark; Winkler, Bärbel; Painting, Rob; Way, Robert; Skuce, Andrew (1 January 2013). "Quantifying the consensus on anthropogenic global warming in the scientific literature". Environmental Research Letters.* ***8*** *(2): 024024. Bibcode:2013ERL8b4024C. ISSN 1748-9326. doi:10.1088/1748-9326/8/2/024024.*

5 *As of this writing (June 2017), no major scientific organizations have made statements against global warming. Two have made noncommittal statements indicating that global warming is taking place but that humans may or may not be responsible and one has stated that they are not qualified to give an opinion. All other professional scientific organizations have made statements in support of the belief that humans are directly responsible for global warming.*

6 *Gallup poll, March 2017: http://www.gallup.com/poll/206030/global-warming-concern-three-decade-high.aspx.*

7 *NASA: What's the difference between weather and climate? https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html*

8 *Climate map: By Adam Peterson (Own work) [CC BY-SA 4.0], via Wikimedia Commons; Weather map: NOAA/NWA, https://graphical.weather.gov/sectors/massachusetts.php.*

- **Vaccines**: Vaccines are agents that give the recipients immunity to a disease. The use of vaccines is directly responsible for the eradication of smallpox, the eradication of polio from the U.S. and Europe, and the prevention of 20.3 million measles deaths worldwide between 2000 and 2015.[9] Even so, a single paper linking the measles/mumps/rubella (MMR) vaccine to autism in 1998 resulted in a anti-vaccine scare, resulting in measles outbreaks in parts of the world where it had been considered all but gone. *The Lancet*, which had published the original vaccine paper, retracted it completely in 2010 in the face of unanimous research showing no link between the MMR vaccine and autism.[10] With a better knowledge of science, perhaps the journalists who loudly proclaimed the original story and those who readily believed it would have been less likely to support unconfirmed claims of a MMR/autism link.[11]

- **Genetically-modified organisms** (GMOs) are organisms that have had their genetic codes changed using gene-altering technology, usually to increase crop yields. Though the scientific consensus is that GMOs are safe to use and safe for human consumption,[12] there is still widespread fear of "Frankenfoods" among the general public. With a greater knowledge of science, GMO crops could more quickly be used to feed the growing numbers of hungry in the world.

GMOs for fun!

In addition to the important uses of genetically-modified organisms above, they've also been used to create the GloFish™, which contain a fluorescent pigment normally found in jellyfish. Though these fish certainly aren't saving the world, they can make aquariums a little more entertaining to look at.[13]

Glofish cost about $5 each.[14]

With increasing scientific literacy, hoaxes and misrepresentations will be less likely to result in outcomes that can harm us all. Of course, there is *always* a need for people to research the possible harm that can be caused from any technology. However, if we let a single bit of *anecdotal* evidence derail the vast body of *scientific* knowledge, there can be lasting effects for us all.

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9 *World Health Organization Measles Factsheet: http://www.who.int/mediacentre/factsheets/fs286/en/*

10 *http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(97)11096-0/fulltext.*

11 *Because I was curious I contacted the Centers for Disease Control and Prevention (CDC) to find out how many deaths could be positively attributed to vaccine use. The answer: Between the years 2002-15, there were a total of 8 deaths in the U.S., https://wonder.cdc.gov/controller/saved/D76/D18F888. Between 1994-2013, over 300 million illnesses, 21 million hospitalizations, and 730 deaths were prevented through routine vaccinations, https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6316a4.htm.*

12 *http://www.popsci.com/article/science/core-truths-10-common-gmo-claims-debunked; http://allianceforscience.cornell.edu/blog/mark-lynas/gmo-safety-debate-over; https://gmo.geneticliteracyproject.org/FAQ/are-gmos-safe/.*

13 *For more info about the science behind Glofish, visit https://www.glofish.com/about/faq/.*

14 *Image provided by www.glofish.com (http://www.glofish.com/images/glofish_005.jpg) [Attribution], via Wikimedia Commons. It has been edited for space.*

Where science is ineffective

There are, however, some hot-button issues that cannot be decided by science alone: Moral issues. For the purposes of this discussion, we will define **morals** as one's belief in what is right.

In 1942, World War II was raging in both Europe and Asia. Because the Allied powers feared that Germany would develop and use the atomic bomb, Canada, the United Kingdom, and the United States started the Manhattan Project. The goal of this project was the construction of an atomic bomb which would bring a quick end to the war.

It was quickly clear that, from a scientific standpoint, an atomic bomb could be built. The underlying theory already existed, so the job of the bomb designers was to figure out how to make it happen. Given that this had never been done before, this involved research in fields such as quantum mechanics, materials science, hydrodynamics, and isotopic separation. Even though the project eventually employed 130,000 people and cost $2 billion ($30 billion in today's money), the project still took three years to complete. This bomb was a wonder of modern science and technology.

The first atomic bomb detonation took place on July 16, 1945 in New Mexico, with an explosive yield of 21 kilotons of energy (equivalent to the detonation of 21,000 tons of TNT).[15]

It did not take long, however, before the scientists involved in building the project asked themselves the following question: *Should* we use the atomic bomb?[16] This question was not one that could be answered using scientific principles. Instead, it was a moral issue based on the values of those who raised it.

This leads to an interesting question: How do we reconcile the possibilities offered by scientific discovery with the moral implications of using new technologies? As yet, there is no good answer to this question.

15 *Photo in public domain, U.S. Dept. of Energy.*
16 *This was known as the Szilard Petition, which was signed in July 1945, before the dropping of the bombs.* *http://atomicheritage.org/key-documents/szilard-petition*

The main ideas in this lesson:

- You need to understand basic science because it will help you to be an informed citizen.
- Though science can answer questions with objective, quantifiable answers, it cannot answer moral questions.

Lesson 3: Glossary

climate: The average weather for an area over a fairly long period of time. If it is raining today for the first time in 100 years, the weather may be “rainy” but the climate will still be “desert.”

genetically-modified organisms (GMOs): Any organism that has had its genetic code changed using gene-altering technology. Some people believe that GMO organisms pose a health or environmental threat, despite a lack of scientific evidence supporting this belief.

global warming: The increase in world temperature over the past hundred years, believed to be caused by mankind's release of greenhouse gases during a prolonged period of industrialization. The term “climate change” is sometimes preferred to describe this phenomenon.

Manhattan Project: The World War II effort to build an atomic bomb. Two bombs were dropped on Japan in August 1945, ending the war.

morals: One's belief in what is right.

social contract: The belief, described by Thomas Hobbes and others, that all people should agree to give up some of their freedom to the government in return for a civilized society. This government will derive its power from the consent of the ruled, making it important to have an informed citizenry.

vaccines: Any agent that bestows immunity to a disease. Though there is no scientific evidence to back it up, some people believe that the administration of vaccines to children can cause a variety of health issues.

weather: The atmospheric activity in some area at a particular period of time. As this is written, the temperature outside is 30° Celsius and it is sunny.

Lesson 3: Practice Sheet

1) In a 1789 letter to Richard Price, Thomas Jefferson stated that “Whenever the people are well-informed, they can be trusted with their own government... whenever things get so far wrong as to attract their notice, they may be relied on to set them to rights.” What do you believe he meant when he said this? Does this have any relevance given what you've learned about the nature of science?

2) Capital punishment is when somebody is executed as punishment for a particularly heinous crime. In recent years, however, there have been a number of cases in which the drugs used in lethal injections have not worked properly, resulting in several botched executions.

   a) For what aspects of the capital punishment debate would science be a good investigative tool?

   b) For what aspects of the capital punishment debate is science *not* a good investigative tool?

3) Do you believe that moral issues will eventually be solved using scientific methods, or vice-versa? Explain your reasoning.

Lesson 3: Practice Sheet Answers

1) In a 1789 letter to Richard Price, Thomas Jefferson stated that "Whenever the people are well-informed, they can be trusted with their own government; whenever things get so far wrong as to attract their notice, they may be relied on to set them to rights." What do you believe he meant when he said this? Does this have any relevance given what you've learned about the nature of science?
The quote given here means that a good government requires well-informed citizens to ensure that the right policies are being followed. If wrong policies are enacted by the government, the citizens will realize it and push their leaders to rethink things and enact better policies. This statement is extremely relevant, given the nature of some of the policies carried out by the government and the way in which some poorly-informed citizens support them.

2) Capital punishment is when somebody is executed as punishment for a particularly heinous crime. In recent years, however, there have been a number of cases in which the drugs used in lethal injections have not worked properly, resulting in several botched executions.
   a) For what aspects of the capital punishment debate would science be a good investigative tool?
   Questions like "What drug causes the least suffering in those being executed?" and "What drug is most likely to effectively execute the condemned?" are questions that are within the purview of science.

   b) For what aspects of the capital punishment debate is science *not* a good investigative tool?
   Science cannot answer the question "Is capital punishment right?"

3) Do you believe that moral issues will eventually be solved using scientific methods, or vice-versa? Explain your reasoning.
This is a question that everyone must answer for himself. However, there are a few commonly-held beliefs on this issue:
   - **Science and morality are different from one another and will not intersect. This belief is held by mainline religious groups and many scientists.**
   - **Morality is the question of "what is best for the most people?" and science can help us to answer it. This belief states, essentially, that morality follows directly from science, and is held by some philosophers.**
   - **Morality is an artifact derived from our evolutionary history. In this view, morality was selected for because it allowed us to pass our genes on more effectively. In this viewpoint, there is no objectively correct morality.**
   - **Moral relativism states that there are no objectively right or wrong statements, but that morals are a product of our society. In this viewpoint, science may or may not have any role to play in morality at all.**

Ultimately, the answer to a question like this is unknowable.

Lesson 3 Activity: Make Your Voice Heard

We've talked about the responsibility that each of us has to become scientifically-literate. In this activity, you'll get a chance to practice this responsibility on your own.

Your job is to write a letter to your congressman, senator, or MP about a position they hold that you believe is scientifically-flawed.[17] Your letter should include each of the following:

- A brief description of the issue.
- An explanation of why the science does not support their position.
- At least three references that support your explanation. These references should be from sources that are generally considered to be nonpartisan and objective.
- Suggestions about how they might change their position to better fit the facts.
- A closing thanking them for their time and consideration.

The issue you choose is up to you and you may hold whatever position you like, provided that it's backed up with scientific evidence. You may use one of the issues discussed in this lesson, or you may choose another that you're interested in.

When you're finished, show your parents the completed letter and mail it.

How to contact an elected official:

- **U.S.**: https://www.usa.gov/elected-officials
- **Canada**: https://www.ourcommons.ca/Parliamentarians/en/members
- **U.K.**: http://www.parliament.uk/mps-lords-and-offices/mps/
- **Australia**: http://www.aph.gov.au/Senators_and_Members/Guidelines_for_Contacting_Senators_and_Members
- **Ireland**: http://www.oireachtas.ie/parliament/contact/
- **New Zealand**: https://www.parliament.nz/en/get-involved/have-your-say/contact-an-mp

17 *If your congressman/senator/MP holds positions you believe are scientifically-correct, you can send a letter to the president or prime minister of your country.*

Lesson 3: Assessment

1) Explain why science literacy is important for everybody, including nonscientists.

2) Based on the information from this lesson and on information you've learned elsewhere, critique the following statement: Only people who are scientifically-literate should be allowed to vote.

3) Do you believe that areas not normally thought of as scientific (i.e. morality, religion, philosophy) will eventually fall under the realm of what we consider scientific? Explain your answer.

Lesson 3: Assessment Answers

Note to parents: Unlike most assessments, this assessment doesn't really have any right or wrong answers. Rather, the "correct" answer will be one that knowledgeably addresses the issues and importance of science literacy. In this sense, the correct answer will reflect both the lesson material and the values with which you've brought up your child.

1) Explain why science literacy is important for everybody, including nonscientists.
Because we live in a democratic society, all people must be well-versed in science to ensure that our representatives make reasonable and correct decisions.

2) Based on the information from this lesson and on information you've learned elsewhere, critique the following statement: Only people who are scientifically-literate should be allowed to vote.
This is a very extreme statement, and not one that most people would consider reasonable. Though science literacy is important, it's not the *only* qualification that people need to be good citizens, nor does everybody need to be scientifically-literate for good decisions to be made. Scientific literacy is something toward which we should strive, not a barrier to participation in democracy.

3) Do you believe that areas not normally thought of as scientific (i.e. morality, religion, philosophy) will eventually fall under the realm of what we consider scientific? Explain your answer.
Different people will have different opinions about whether this will be the case, and there is no single correct answer. When looking at answers to this question, it is the reasoning behind the answer that's most important, not the answer itself. Good answers should discuss the relationship of science with morality/religion/philosophy, and address the issue of whether these subjects represent a current limitation of science or are inherently different from it.

Lesson 3: References For Further Study

Global warming and climate change

- Skeptical Science: The 97% consensus on global warming (https://www.skepticalscience.com/global-warming-scientific-consensus.htm): A good discussion of how one's scientific expertise affects one's opinion about global warming.[18]

GMOs

- Why People Oppose GMOs Even Though Science Says They're Safe (https://www.scientificamerican.com/article/why-people-oppose-gmos-even-though-science-says-they-are-safe/): This article explores how one's emotions can affect how they see scientific truth.

Vaccines

- Too Many Vaccines? (http://www.vaccinateyourbaby.org/safe/autism/overburdening.cfm): Though brief, this article discusses the safety record of vaccines and how they're tested. Additionally, there are references discussing the difficulties with "alternative" vaccination schedules.

Science and Morality:

- The New Science of Morality (https://www.edge.org/event/the-new-science-of-morality): How emotion, brain chemistry, and other factors affect our sense of morality.
- The Moral Challenge of Modern Science (http://www.thenewatlantis.com/publications/the-moral-challenge-of-modern-science): An in-depth discussion of how the idea of a morally-neutral science came to be and whether it's reasonable to believe this is true.

18 *It links to the Petition Project, a petition signed by 31,000 scientists who believe global warming isn't occurring. After searching five signers at random, I found that one was not a scientist, one was a discredited scientist, one had never published anything, one was a doctor of geriatric medicine, and one had specialized in poultry husbandry. This is an important reminder that just because somebody claims to be a scientist, they may not actually have the qualifications to make an informed decision.*